University of Alberta

Mass Transfer between Pentane and Heavy Hydrocarbons

by

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Abstract

The demand for accurate bitumen + pentane mass transfer data was the main motivation behind this research. Difficulties such as complex phase behaviour, high viscosity and opacity of the hydrocarbon invariably lead to failure of conventional techniques to measure mass transfer coefficients involving heavy oils. To address this issue, X-ray transmission tomography has been employed for such measurements. The initial set of experiments in this study measured the free mutual diffusion coefficient of pentane + Athabasca bitumen, as well as pentane + atmospheric residue. In addition, forced mass transfer between pentane and both bitumen and atmospheric residue was studied. Forced mass transfer between pentane and these two heavy oils followed a similar pattern when normalized and the pattern is consistent with prevailing understanding. However, mass transfer rates between pentane and Athabasca atmospheric residue are one order of magnitude smaller than for the corresponding bitumen case. Impacts on the effectiveness of proposed production and refining processes are discussed.

Acknowledgments

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Nomenclature

A	Surface Area
c	Velocity of light in vacuum
D_{12}	Mutual Diffusion Coefficient
d_i	Impeller diameter
d_v	Vessel diameter
h	Interface level height
I	Intensity of transmitted beam
I_0	Intensity of the incidental beam
K	Mass transfer coefficient
K_{int}	Mass transfer coefficient calculated by monitoring interface level
K_{bulk}	Mass transfer coefficient calculated by monitoring bulk concentration
M_i	Mass of component I
N	Rotation speed
t	Time
w_i	Mass fraction of component i
X	Composition
x	Thickness
λ	Wavelength of X-ray beam
λ_e	Effective wavelength of polychromatic X-ray beam
μ	Mass absorption coefficient

μ_i	Mass absorption coefficient of component i for a monochromatic X-ray beam at wavelength λ
μ_{ij}	Mass absorption coefficient of component i for a polychromatic X-ray beam at a wavelength of λ_j.
ρ	Density
υ	Velocity of light in Desired phase
δ	Boundary layer thickness

1. Introduction

The global demand for energy is rising at a time when production of convenient energy resources, such as conventional oil and gas, is declining. As a result, the energy industry is increasingly focusing on unconventional energy resources such as heavy oils and bitumen. For example, much research has been targeted at improving recovery rates from reservoirs and improving the efficiency of bitumen extraction from tar sands through technology development [1]. The success of the proposed or revised process designs will rely on accurate knowledge of thermophysical and transport properties as these impact the scale and feasibility of the proposed infrastructures.

For example, successful solvent extraction in vessels depends critically on accurate diffusion coefficient and mass transfer measurements between the solvent and the mined lumps. Production rates of bitumen or heavy oil from a reservoir for processes where hydrocarbons are injected depend on how rapidly the light hydrocarbons can penetrate the undisturbed and quiescent heavy oil resource. This process is influenced also by the value of the mutual diffusion coefficient, within the hydrocarbon resource, and the hydrodynamic conditions at the boundary between the undisturbed heavy hydrocarbon and the solvent rich liquid or dense vapour. Different applications (e.g. Vapex and Solvent extraction techniques) result in different boundary conditions between the solvent and the heavy oil. These vary from a stagnant gas-liquid or to a mixed liquid-liquid interface in vessels where mass transfer is controlled by the hydrodynamic conditions at the interface.

Analogous studies, in particular, the work by Tao et al[2] were found to be quite helpful in framing the scope of this thesis, which comprises a combination of diffusive and forced mass transfer measurements at bitumen and bitumen atmospheric residue + pentane interfaces. As bitumen constituents + organic solvent mixtures may exhibit up to four phases in equilibrium [3] and that the density differences among the phases are significant, experiments with bitumen + organic solvents face both theoretical and experimental challenges.

Recent work on mutual diffusion coefficient measurements in Athabasca bitumen + pentane [4, 5] highlighted the need for improvement in both the experimental and data analysis techniques. Prior work by Gou's group [6] demonstrated that indirect measurement techniques (e.g. the pressure decay method by Riazi, Tharanivasan et al[7]) did not produce sufficiently accurate results yield errors ranging up to 2 orders of magnitude. Only direct measurement of concentration profiles can provide a reliable basis for mutual diffusion coefficient determination. Further, these researchers showed that in analysing concentration profile data where density gradients among constituents are large, density gradients must be considered. If such information is not included in the analysis, two artefacts are introduced: First, mutual diffusion coefficients obtained from the concentration profile data are time dependent. Values are several orders of magnitude too high at short contact times where concentration gradients are large. Second, values in the mid-range of the concentration remain too large even at long contact times due to density gradients. Mutual diffusion coefficient values are, by definition, time independent. They are less than the self-diffusion coefficient for the penetrant in the liquid state at the same operating conditions, where the penetrant molar mass is significantly smaller than that of the reservoir fluid [8].

Improvements in the spatial resolution of concentration profiles, as well as the precision of composition measurements, were also pursued as these experimental advancements were expected to yield mutual diffusion coefficient values with significantly reduced random error relative to the prior work. For example, Zhang et al,[4, 5] reported constant values for liquid-phase mutual diffusion coefficients (D_{12}) of $1.7 \pm 0.4 \times 10^{-10}$ m^2s^{-1} for bitumen in pentane at 295 K over the composition range ($w2$) (0.1 to 0.9). In their work, the spatial resolution of the concentration profiles was ~ 375 μm. They also reported diffusion coefficients (D_{12}) values of $1.5 \pm 0.5 \times 10^{-10}$ m^2s^{-1} for Cold Lake bitumen + heptane mixtures over a similar composition interval, based on concentration profiles with a spatial resolution of 600 μm [9]. Improved spatial resolution and local concentration measurement would also facilitate the evaluation of the composition dependence of mutual diffusion coefficients as anticipated from theory. Reduced measurement error would also allow researchers to determine whether possible asphaltene aggregate accumulation at the bitumen-pentane interface would become a significant impediment to mass transfer over time. Asphaltene aggregate density is known to be greater than the densities of the hydrocarbon resource and pentane. John Nenniger raised this latter point [private communication] as he is concerned about the potential for underestimation of penetration rates in batch experiments vis-à-vis field measurements or large scale experiments [10]. In batch experiments, the interface is horizontal (with the lower density penetrant situated on top, and the higher density hydrocarbon resource at the bottom). In field measurements, the hydrocarbon resource-penetrant interface orientation is variable and asphaltene accumulation is therefore less likely to arise at the interface, irrespective of the prevailing hydrodynamic conditions in the penetrant.

2. Literature review

2.1 Measurement Techniques employed for diffusion coefficient measurement with bitumen and heavy oil

To determine the concentration profile, various methods have been utilized. In this section, the more common and modern methods will be introduced:

1- Pressure Decay Method

2- Refractive Index

3- MRI

4- Computer-Assisted Tomography

5- X-ray transmission tomography

2.1.1 Pressure Decay Method

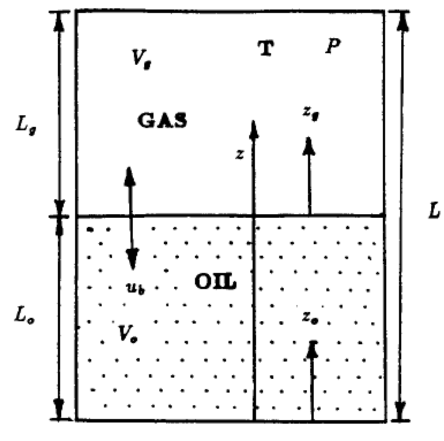


Figure 2-1 Constant volume cell

In this method, gas and oil are injected into a fixed volume cell (Figure 2-1). The cell content is initially at a non-equilibrium state. As the experiment progresses, the gas dissolves into the oil and the pressure inside the cell decreases as a result. By recording the pressure and the level of the liquid in the cell, the amount of gas transferred into the oil can be determined. From this, the diffusion coefficient is calculated. The diffusion coefficient determined by this method is the apparent diffusion coefficient. In cases involving complex hydrocarbon mixtures with possible multiphase behaviors, the pressure decay method fails. Detailed mathematical procedures which are used to calculate the diffusion coefficient are available through the original paper [7]. This method, however, had been discredited by Luo and Gu[6]. They showed that, minor changes to assumptions related to boundary conditions led to orders of magnitude differences in reported values.

2.1.2 Refractive Index

Refractive index [11] is the ratio of the velocity of wave propagation in a reference phase to that in the phase of interest. Normally, the refractive index used in diffusion measurement is taken as the ratio of the velocity of light in vacuum to the velocity of light in the relevant phase (Equation 2-1).

$$n = \frac{c}{v}$$

Equation 2-1

where *n* is the refractive index, *c* is the velocity of light in vacuum, and *v* is the velocity of light in the phase of interest. With the velocity of light in vacuum chosen as the reference, the refractive index is always greater than 1. Equation 2-2 shows the relation between the angles of refraction and the refractive index:

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

Equation 2-2

It is noted that, for a solution, different concentrations of a sample substance will lead to different refractive indices. As a result, from the angle of refraction, the concentration of a solution phase can be determined.

Normally, in experimental measurements of refractive indices, a laser light is emitted through the diffusion cell and, according to the concentration of the solution at each elevation, the corresponding refractive angle of the laser beam is determined. As a result, the point at which the laser beam is captured by a CCD camera will represent the concentration inside the diffusion cell at that specific elevation. Figure 2-2 shows a sample picture of CCD during the diffusion process.

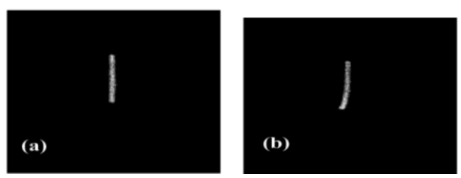


Figure 2-2 Sample of light refraction results a) initial time b) after diffusion occurred

It is noted that the above method is suitable only for transparent fluids. As heavy oil, even when diluted, is opaque, such a method cannot be employed.

2.1.3 MRI

Magnetic resonance imaging (MRI) was mainly developed for medical usages. The principle of this method is to calculate the density of hydrogen protons. It is a very powerful method for water diffusion measurements, but with the presence of other hydrogen protons (e.g. from hydrocarbons), this method fails. However, in other cases such as calculating the diffusion of a hydrocarbon into a catalyst, MRI can be very useful. A sample image of MRI is shown in Figure 2-3. This picture demonstrates the amount of water in different parts of a polymer film [12].

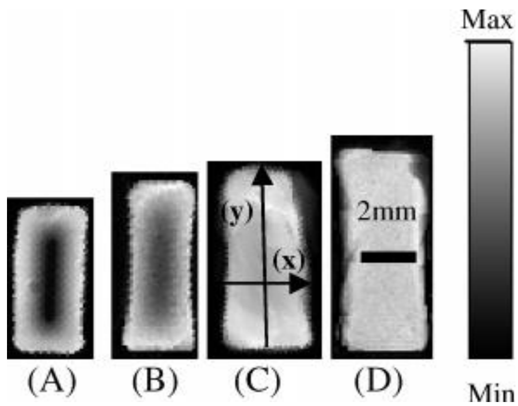


Figure 2-3 MRI image of a Polymer Film. Brighter image represents more water

The low resolution of MRI, along with the unidentifiable nature of heavy oil components, are the most important reasons that this method is not suitable for studying heavy oil mixtures. Moreover, previous studies using this method lacked appropriate data analysis [12].

2.1.4 Computer-Assisted Tomography

X-ray CAT scanning is a conventional technique used to monitor and characterize reservoir rock and flows within them. Wen and Kantzas [13] used this method to monitor the concentration profiles at a bitumen-solvent interface. This technique generates appropriate data but their their concentration profile data were not analysed appropriately, resulting in time dependent diffusion coefficients. When density gradients are accounted for, the results obtained are excellent[4].

2.1.5 X-ray transmission tomography

The principal of this method is the same as that for medical X-rays[4]. The amount of X-ray absorbed by a substance is a function of the density of the substance and the path length through that substance — Equation 2-3.

Equation 2-3

$$I = I_0 e^{-\rho \Delta x \mu}$$

A Schematic of the experimental setup is shown in Figure 2-4.

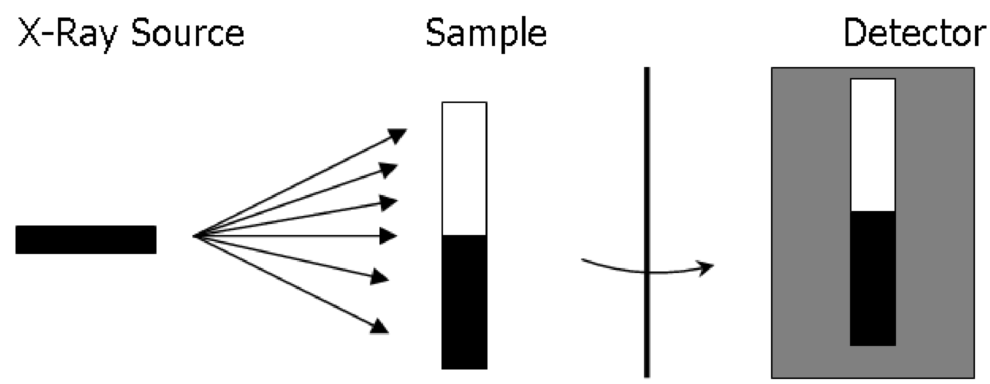


Figure 2-4 Schematic view of experimental setup

By averaging the intensities at each elevation, a transmitted intensity vs elevation curve can be constructed.

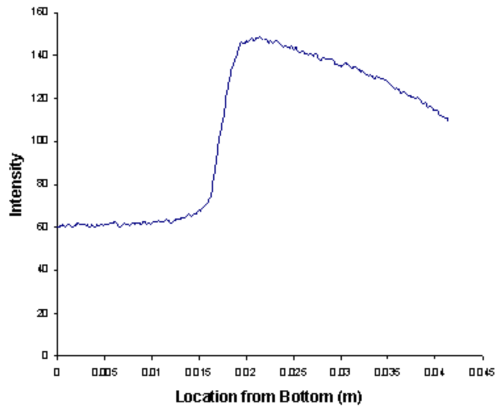


Figure 2-5 Data analysis

If the mixture is assumed to be ideal (ΔVmix = 0), and absorbance is not a function of composition, then from Equation 2-4, the intensity profile can be transformed to a concentration profile for a binary mixture.

Equation 2-4

$$w_1 \sim \frac{\ln\left[\dfrac{I}{I_{bitumen}}\right]}{\ln\left[\dfrac{I_{pentane}}{I_{bitumen}}\right]}$$

The main advantage of this method is its ability to operate with opaque solutions such as bitumen + pentane, and the spatial resolution of the measurements.

2.2 Pentane + Bitumen Mutual Diffusion Coefficients

Different mutual diffusion coefficients have been reported in the literature for similar heavy oil + organic solvent mixtures. Reported values cover a wide range which differs by 3 orders of magnitude (e.g. Das 1996, Wen 2005, and Zhang 2007). Das and Butler [8], who employed a Hele-Shaw cell, reported values as high as10^{-7} m^2/s as mutual diffusion coefficient of propane + bitumen mixtures. Such values are an order of magnitude larger than the liquid phase self diffusion coefficient for propane under the same experimental conditions. Time dependent mutual diffusion coefficients have also been reported for pentane + bitumen [13]. However, the time dependency for mutual diffusion coefficients is inconsistent with known physics and reflects inadequate data analysis. Zhang and Shaw [4] reported time independent values for mutual diffusion coefficients for bitumen + pentane (Table 2-1). These appear to be the most reliable values available in the literature and are much smaller than anticipated for bitumen diffusing in pentane at infinite dilution.

Table 2-1 Liquid-phase mutual diffusion coefficients D_{12} for pentane-bitumen mixtures

w	10^{10} D_{AB} m^2/s	w	10^{10} D_{AB} m^2/s
0.1	1.8	0.55	1.4
0.15	1.9	0.6	1.4
0.2	1.7	0.65	1.6
0.25	1.5	0.7	1.6
0.3	1.4	0.75	1.9
0.35	1.4	0.8	2.2
0.4	1.4	0.85	2
0.45	1.4	0.9	2.2
0.5	1.4		

2.3 Forced Mass transfer measurements in bitumen + organic solvent mixtures.

There are no direct data available for heavy oil + organic solvents; however, analogous measurements have been made for diverse mixtures in stirred vessels. Mamidi et al[14] developed a new experimental technique to measure the mass transfer rate at different mixing rates for large molecules; Tao et al[2] studied cholesterol dissolution and observed various controlling mass transfer resistances at different mixing rates; Gregory and Riddiford[15], Gharehbagh et al[16], Tezura[17] and Geankoplis[18] studied the dissolution of various materials into electrolytes. As the mixing rate was increased, all of the above studies reported a shift from hydrodynamically-controlled mass transfer due to conditions at the liquid interface to mass transfer that was independent of hydrodynamics but dependent on another rate limiting phenomena such as chemical reaction.

2.4 OBJECTIVES

Large inconsistencies in the available data in the literature, along with the lack of proper measurement techniques and data analysis for determining both the mutual diffusion coefficients and mass transfer coefficients, have been the motivation for this research. The two main objectives for this study are the assessment of apparatus improvements and the provision of reliable diffusion and mass transfer data for process design and development applications.

3. Governing Equations and Theory for Mass Diffusion

Mutual diffusion coefficients can be obtained from analysis of experimental data, in particular, by fitting solutions of the diffusion equation to experimental composition profiles. The diffusion equation and its derivation are available from numerous references written in diverse contexts. Three pertinent standard reference texts are readily available: (Bird et al., 2002; Poling et al., 2001; and Basmadjian 2005). Key aspects of the defining equations and the computational methods employed are only briefly mentioned here as details are available elsewhere [4, 5].

We start with the one-dimensional equation of continuity for a binary mixture in the absence of chemical reaction and bulk flow:

Equation 3-1

$$\left[\frac{\partial(\rho(w_2)\bullet w_2)}{\partial t}\right] = \frac{\partial}{\partial x}\bullet \rho(w_2)D_{12}(w_2)\left[\frac{\partial w_2(x,t)}{\partial x}\right]$$

Here, x is the spatial coordinate, t is the time, D_{12} is the mutual diffusion coefficient, w_2 is the composition of component 2, and ρ is the density. Next, one obtains Equation 3-2 by allowing for the variation of density and diffusivity with composition:

Equation 3-2

$$\frac{\partial D_{12}}{\partial w_2} + D_{12}\left\{\frac{\partial \rho}{\partial w_2}\frac{1}{\rho} + \frac{\partial^2 w_2}{\partial x^2}\bigg/\left[\frac{\partial w_2}{\partial x}\right]^2\right\} = \left[1 + \frac{w_2}{\rho}\frac{\partial \rho}{\partial w_2}\right]\frac{\partial w_2}{\partial t}\bigg/\left[\frac{\partial w_2}{\partial x}\right]^2$$

Direct analysis of the composition profiles leads to composition derivatives with time at fixed position, and with space at fixed time. If the density is assumed to vary linearly with composition in the construction of composition profiles, the density derivative with composition is constant. In the absence of a general theory for the variation of actual diffusion coefficients with composition, one can express the mutual diffusion coefficient and its derivative with composition as a Taylor series expansion in composition:

Equation 3-3

$$D_{12} = \alpha + \beta(w_2) + \varepsilon(w_2)^2 + \gamma(w_2)^3 + \kappa(w_2)^4 .....$$

and

Equation 3-4

$$\frac{\partial D_{12}}{\partial w_2} = \beta + 2\varepsilon(w_2) + 3\gamma(w_2)^2 + 4\kappa(w_2)^3 ....$$

Equation 3-3 and Equation 3-4 can be substituted into the objective function, Equation3-5, where the value is minimized to obtain values for the parameters.

Equation3-5

$$o.f. = \frac{1}{n}\sum_{1}^{n} \text{abs}\,[\frac{\partial D_{12}}{\partial w_2} + D_{12}\left\{\frac{\partial \rho}{\partial w_2}\frac{1}{\rho} + \frac{\partial^2 w_2}{\partial x^2} \Big/ \left[\frac{\partial w_2}{\partial x}\right]^2\right\} - \left[1 + \frac{w_2}{\rho}\frac{\partial \rho}{\partial w_2}\right]\frac{\partial w_2}{\partial t} \Big/ \left[\frac{\partial w_2}{\partial x}\right]^2 \,]$$

Here, n is the number of measurements in a composition profile. Typically, n exceeds 100 and the number of universal coefficients is four, namely α, β, ε and γ. All other coefficients are set to zero. As temporal and spatial derivatives are required, a minimum of three concentration profiles are regressed simultaneously.

3.1 Mass Transfer Rate Calculation

The mass of bitumen transferred across the bitumen-pentane interface is computed from two independent measurements that are cross-checked. First, Equation 3-6 is used to calculate the bitumen mass transferred to the pentane-rich liquid, with a pentane mass fraction w_2, where the mass of pentane is fixed at M_2. The pentane is assumed pure initially:

Equation 3-6

$$M_1 = \frac{(1 - w_2)}{w_2} M_2$$

Differentiating Equation 3-6 with respect to time leads to the bitumen mass flux:

Equation 3-7

$$\frac{1}{A}\frac{\partial M_1}{\partial t} = \left[\frac{M_2}{A}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$$

The change in composition of the well-mixed pentane rich phase can readily be measured experimentally.

Second, monitoring the elevation of the interface also provides a bitumen mass transfer value. As the interfacial area is fixed, Equation 3-8 provides a measure of the mass flux:

Equation 3-8

$$\frac{1}{A}\frac{\partial M_1}{\partial t} = -\rho_{Bitumen}\frac{\partial h}{\partial t}$$

where h is the bitumen interface elevation. Again, it is relatively straightforward to determine the interface elevation experimentally.

Equation 3-7 and Equation 3-8 are valid whether the bitumen is soluble or only partially soluble in pentane, as long as it is dispersed and moves from the interfacial region.

For miscible solutes, the mass flux across the interface is given by

Equation 3-9

$$\frac{1}{A}\frac{\partial M_1}{\partial t} = K w_2 \rho_1$$

where K is the mass transfer coefficient, ρ_1 is the density of the solute, and A is the interfacial area. Equation 3-9, which is an expression for the mass transfer coefficient, is the result of combining Equation 3-7 and Equation 3-9:

Equation 3-10

$$K = \left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$$

Bitumen is only partially soluble in pentane at room temperature. The asphaltene + inorganic matter fraction (~ 19 wt% of the sample) is certainly insoluble. However, such components do disperse. Equation 3-9 may overstate the composition dependence for mass transfer. If we consider the opposite asymptotic case, i.e., if the bitumen is insoluble, then one obtains:

Equation 3-10

$$K = \left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$$

It is not clear whether the exponent of the power dependence on pentane composition should be a “2” (insoluble but dispersed) or a “3” (soluble). In principle, this can be resolved on the basis of experimental data.

3.2 Boundary Layer Theory

Boundary layer theory, or film theory, is the simplest model that relates the mass transfer rate to boundary layer thickness. This model assumes the presence of a laminar layer on the boundary where only molecular diffusion is occurring [19]. Beyond this, the model relates the mass transfer rate to the boundary layer thickness (δ):

Equation 3-11

$$\frac{1}{A}\frac{\partial M_1}{\partial t} = K(w_{A1} - w_{A2}) = \frac{D_{AB}}{\delta}(w_{A1} - w_{A2})$$

Equation 3-12

$$K = \frac{D_{AB}}{\delta}$$

Here, K is the mass transfer coefficient, δ is the boundary layer thickness, D_{AB} is the mutual diffusion coefficient, and w_{A1} is the A concentration at point 1.

3.3 Forced Mass Transfer

The mass transfer rate is a function of the shear field intensity adjacent to the interface as described by Equation 3-13 [20]:

Equation 3-13 Laminar mass transfer coefficent

$$k = 1.86\left(\frac{vD^2}{dL}\right)^{1/3}$$

where v is the solute velocity, D is the solute diffusivity, d is the mixer diameter, and L is characteristic length of the system. In addition, the following equations predict the mass transfer coefficient in turbulent flow:

Equation 3-14 Turbulent mass transfer coefficient for solid-liquid system

$$\frac{k\ d_v}{D} = 0.402\left(\frac{d_i^2 N\rho}{\mu}\right)^{0.65} Sc^{0.33}$$

Equation 3-15Turbulent mass transfer coefficient for liquid-liquid system

$$\frac{k\ d_v}{D} = 0.052\left(\frac{d_i^2 N\rho}{\mu}\right)^{0.833} Sc^{0.5}$$

$$Sc = \frac{\mu}{\rho D}$$

where d_v and d_i are the vessel diameters, ρ and μ are mixed phase density and viscosity, D is the diffusion coefficient, and N is the rotation frequency.

3.4 Error Analysis

Using all eight of the experimental concentration profiles for a given case and minimizing the cumulative objective function (Equation3-5) results in time independent diffusion coefficients as a function of concentration (equation 3-3). These values are reported in the Tables and in the Figures. Diffusion coefficients fit to combinations of three concentration profiles within the data set were also determined. The reported errors reflect the range of diffusion coefficients determined at different times. Care was taken not to over fit the concentration profile data which has an error of +/- 0.2 wt %.

The error in mass transfer rate calculation is a result of uncertainties in bulk concentration measurement and interface detection. The nature of this error is linked to the spatial resolution and intensity sensitivity of the camera, which affects both composition measurement and interface location determination. For example, a +/- one pixel error in interface elevation corresponds to 150 µm; a +/- one shade of intensity out of the 204 shade difference between the bitumen or atmospheric residue and pentane corresponds to a 0.5 wt % error. However, as intensity is measured at 38 locations at each elevation in each image and 100 images are averaged per measurement, the corresponding measurement errors are 75 um and 0.25 wt % respectively.

4. Materials and Methods

4.1 Experimental Apparatus

The experimental program of this study was conducted using an X-ray view cell apparatus. It consisted of three major parts: (1) Phillips MCN-165, Tungsten-target bremsstrahlung X-ray gun with spectral endpoint energies between 5 and 160 keV, (2) sample holder, and (3) X-ray detector (micro photonics X-ray imager LA 115mn) as shown in Figure 4-1.

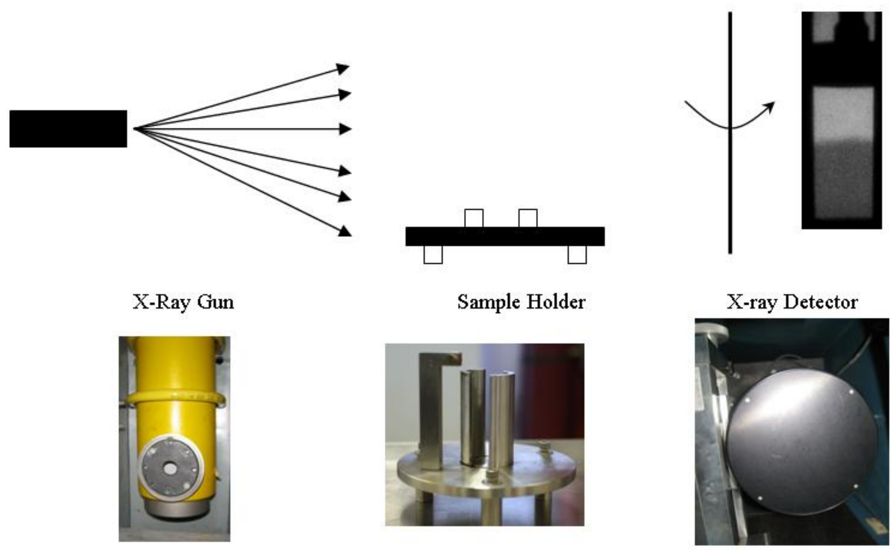


Figure 4-1 Schematic of the X-ray view cell apparatus

The principles of the experimental apparatus are described in Chapter 2 and a detailed description is available elsewhere [4]. Here, we describe only the experimental setup and procedural details relevant to this study.

A cylindrical glass tube (internal diameter 37 mm, length 130 mm) is employed as the diffusion cell (Figure 4-2). Bitumen or heavy oil is placed at the bottom of the cell and a less dense solvent is introduced at the top.

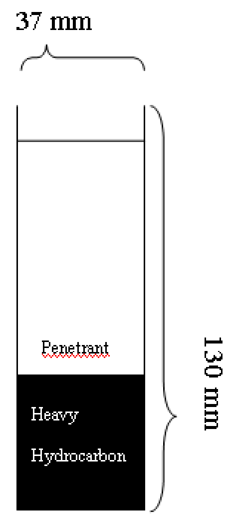


Figure 4-2 Diffusion Cell

4.2 Calibration

Local X-ray intensities obtained from pure solvent and pure heavy oil as functions of elevation constituted the calibration. Pure heavy oil and pentane intensity profiles used as calibration background are presented in Figure 4-3. A curved X-ray intensity profile is observed for pure substances because the x-ray source is a point source. Sample thicknesses varied with elevation. The maximum local intensity for a pure substance is in line with the X-ray source position. As the heavy oil normally has higher density compared to the solvent, the pure heavy oil sample produced the minimum X-ray intensity or the darkest section of the transmitted image, and pure solvent resulted in the brightest part of the image. Any mixture of solvent and heavy oil will result in local X-ray intensities that fall between the pure heavy oil and solvent intensities. The local mass fraction is related to the local X-ray intensity as shown in Equation 2-4. Transformation from X-ray transmitted images to concentration profiles was performed in two stages as shown in Figure 4-4.

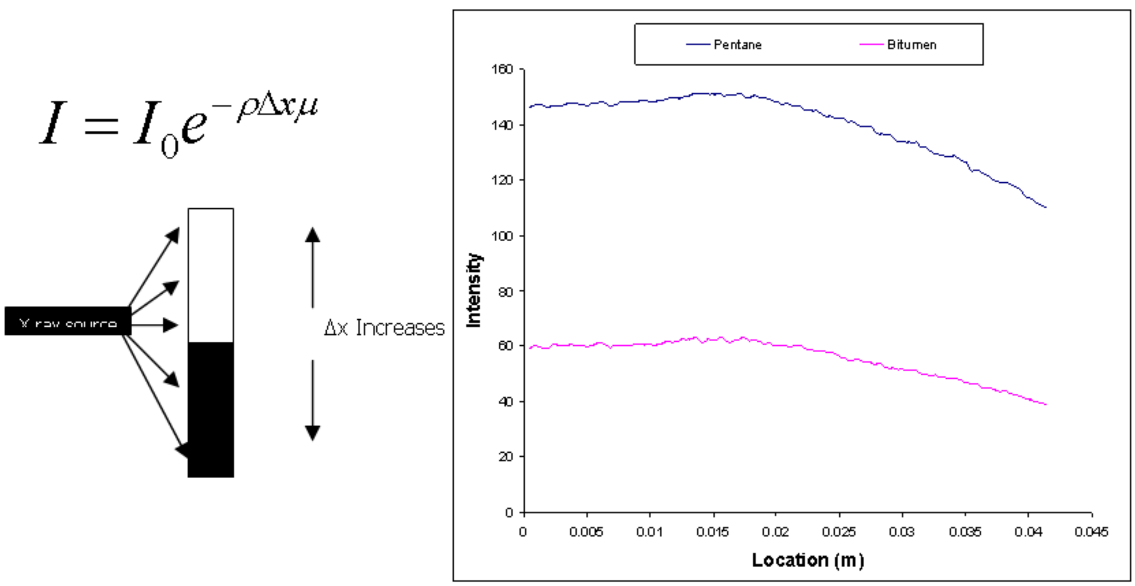


Figure 4-3 Pure pentane and bitumen employed as callibration backgournd

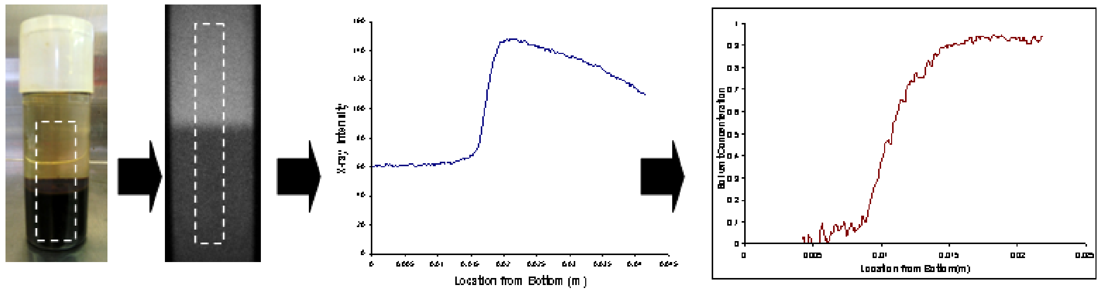


Figure 4-4 Transformation from X-ray transmitted image to concentration profile

The transformation from X-ray image to X-ray intensity profile was done using MATLAB (Appendix I). To minimize the effect of noise on the transformation, 38 pixels were averaged at each elevation (Figure 4-5), from 100 consecutive images taken at 0.03 s per image (Figure 4-6). The transformation of intensity profiles to concentration profiles was performed using a spreadsheet program Microsoft Excel (Appendix 2). The impact of smoothing on the resulting composition profiles is illustrated in Figure 4-7 for a mixture of 80 mL pentane + 20 mL bitumen at 23º C and atmospheric pressure.

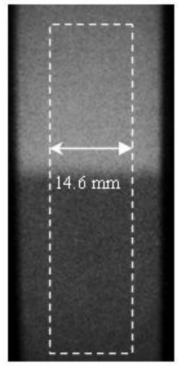
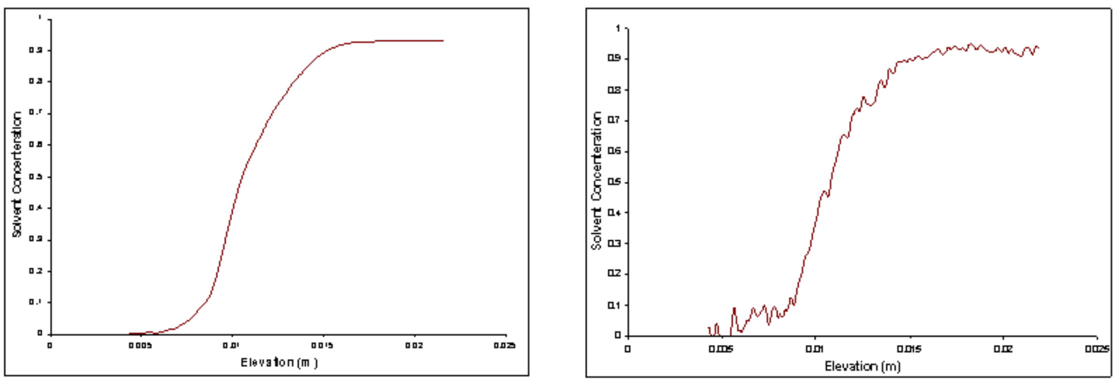


Figure 4-5 Portion of the image utilized for data analysis



(a) (b)

Figure 4-6 Averaging 100 X-ray transmitted images to produce a smoother concentration profile. (a) averaged image (b) normal image

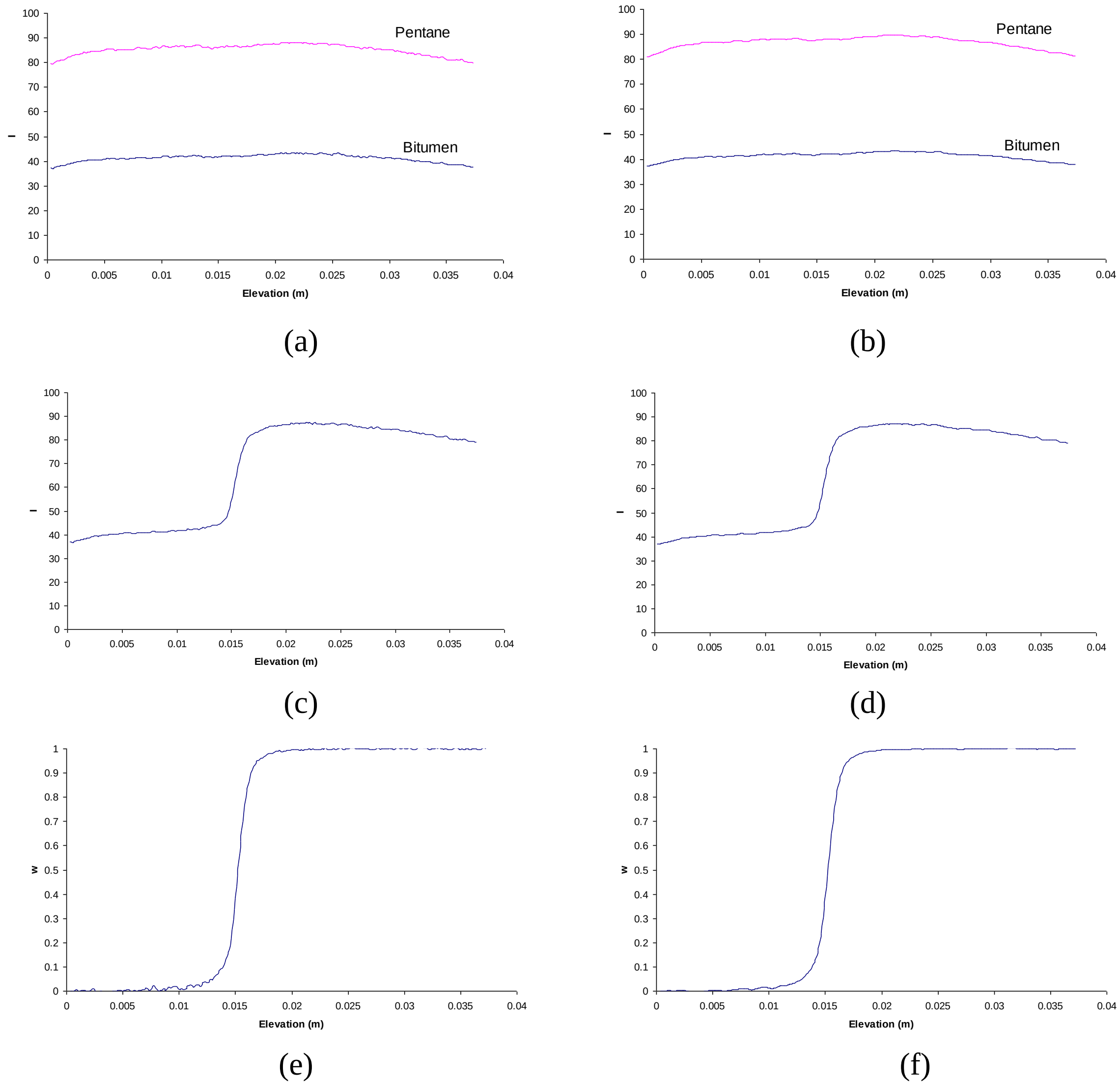


Figure 4-7 Composition and x-ray intensity profiles. (a) Bitumen and pentane intensity profile; (b) smoothed bitumen and pentane intensity profile; (c) pentane over bitumen intensity profile; (d) smoothed pentane over bitumen intensity profile; (e) pentane mass fraction profile through the diffusion cell; (f) smoothed pentane mass fraction profile through the diffusion cell.

4.3 Sample Preparation

The mutual diffusion coefficients for Athabasca bitumen and pentane were measured at 295 K using the free diffusion method. A cylindrical glass tube (internal diameter 37 mm, length 130 mm) was employed as a diffusion column in which 99 wt% of anhydrous pentane was gently injected on top of the denser hydrocarbon (heavy oil) sample. The compositional changes that occurred were monitored by measuring variations of local transmitted X-ray intensity. Mass transfer rates were studied by placing a turbine impeller 1.5 cm above the initial interface. The rotational speed of the impeller was controlled using an IKA RW 16 controller (purchased from Fisher scientific) that was calibrated with an optical tachometer. The concentration of the heavy oil in the pentane rich phase, as well as the elevation of the undisturbed heavy oil, were monitored continuously (using video and video stills). A general schematic of the setup and a series of details are shown in (Figure 4-1).

4.4 View Cell Upgrades

The X-ray image capture system employed in prior work was replaced with a microphotonics X-ray imager LA 115mn. The spatial resolution was improved from 375 µm/pixel to 150 µm/pixel in the vertical direction. This improvement in telemetry was combined with automation of the image acquisition and processing software. A hundred individual video stills, captured over a three second interval at 0.03 s/frame, were then averaged across 7 vertical pixels at each elevation. These composite images, obtained over a time interval that was short relative to the time scale of diffusion and mass transfer, had significantly less noise and superior spatial resolution relative to our previous measurements.

4.5 Well-Mixed Test

All of the equations employed to calculate the mass transfer rate are based on the assumption that the pentane-rich phase is well mixed (i.e. uniform concentration profile). To check the validity of this assumption, heavy oil concentration was measured as a function of elevation both above and below the impeller for bitumen-pentane mixture at 2.31 Hz (the minimum mixing rate) for 0.3-, 1.1- and 3-hour durations (Figure 4-8). Similar results were found for all cases explored. Thus the well mixed assumption appeared to be valid.

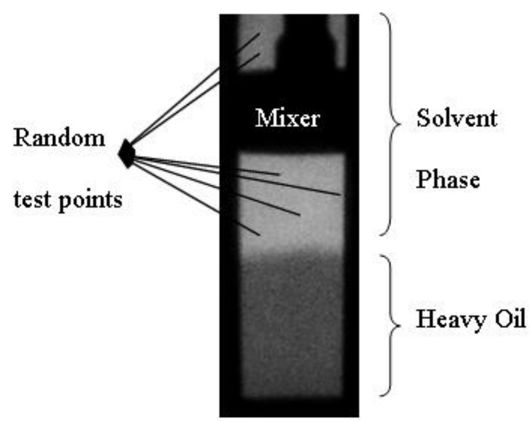


Figure 4-8 Well-mixed test points

5. Results and Discussion

5.1 Mutual Diffusion Coefficient for Pentane + Athabasca Bitumen and Atmospheric Residue

5.1.1 Bitumen + Pentane

The first set of experiments consisted of 20 mL of Athabasca bitumen and 80 mL of pentane at 24ºC and atmospheric pressure. The resulting X-ray intensity profiles are shown in (Figure 5-1), and the pentane mass fraction profiles are shown in (Figure 5-2).

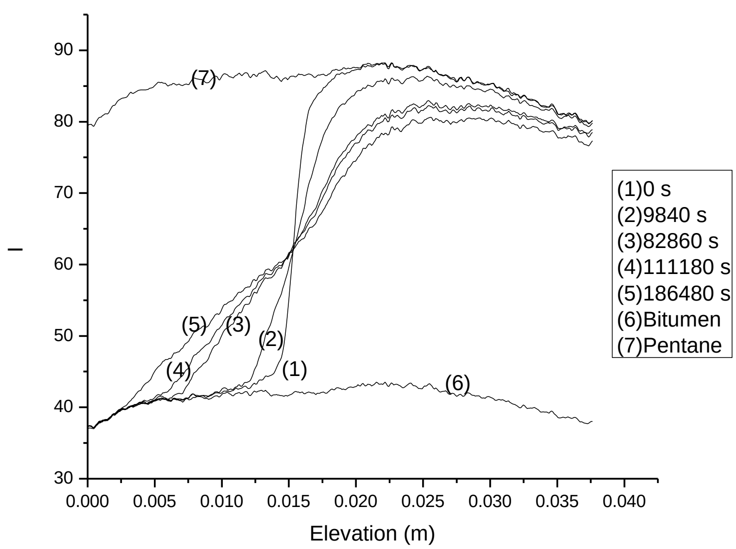


Figure 5-1 Free diffusion of 20 mL Athabasca bitumen + 80 mL pentane. X-ray intensity profiles at different times are shown.

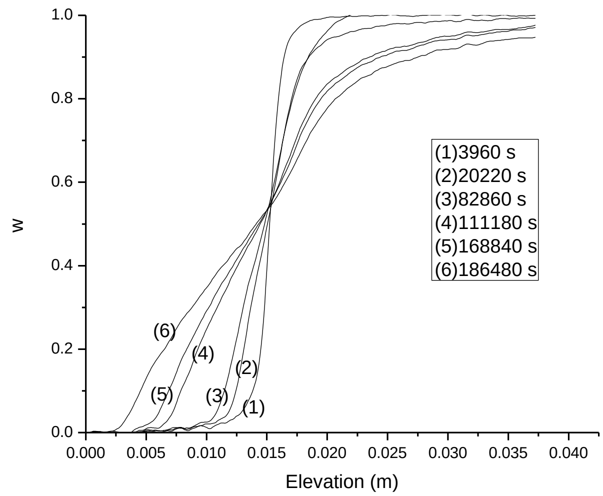


Figure 5-2 Pentane mass fraction profiles at different times.

As seen in Figure 5-2, the compositional profiles all pivot around a single point, suggesting that the global composition, *w* = 0.055, was time invariant. Pentane evaporation was clearly not occurring.

Values of the mutual diffusion coefficient for different pentane concentrations were obtained following the mathematical procedures described in Chapter 3; these results are presented in Table 5-1. The parameters appearing in Equation 3-3 for this case are: $\alpha=1.41*10^{-10}$ m^2/s, $\beta=3.19*10^{-11}$ m^2/s *, $\varepsilon=7.75*10^{-12}$ m^2/s and $\gamma = 1.58*10^{-11}$ m^2/s. These were fit to the composition range 10 wt % to 90 wt%.

Table 5-1 Mutual diffusion coefficients, pentane + Athabasca bitumen

Pentane mass fraction	D_{AB} (m^2/s)	Error (m^2/s)
0.2	1.4E-10	2E-11
0.3	1.5E-10	2E-11
0.4	1.5E-10	2E-11
0.5	1.6E-10	8E-12
0.6	1.6E-10	2E-12
0.7	1.7E-10	9E-13
0.8	1.7E-10	8E-13
0.9	1.8E-10	6E-11

These results are in good agreement with values reported previously for the same mixture[4], as shown in Figure 5-3.

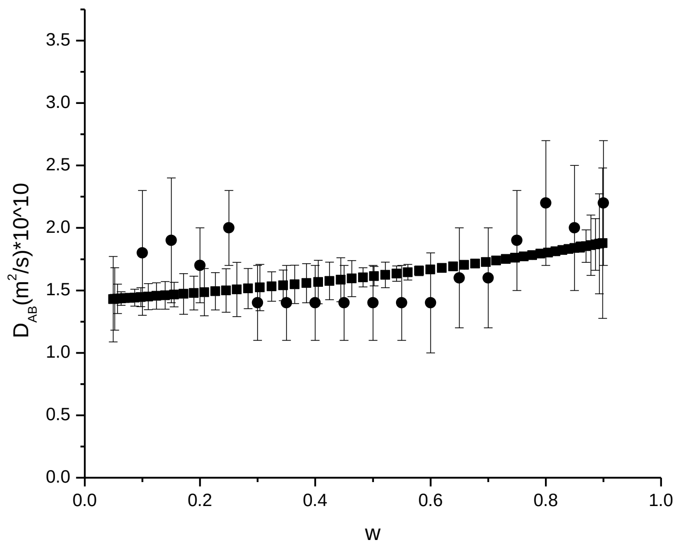


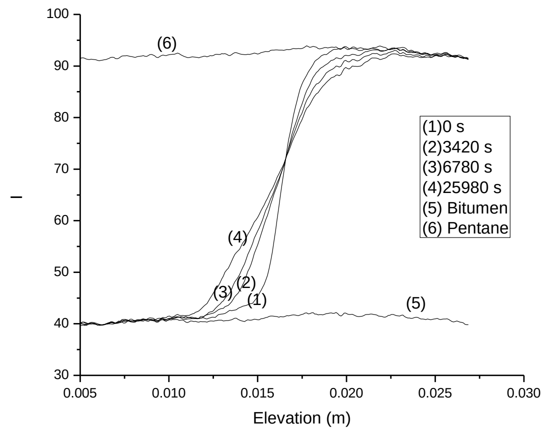
Figure 5-3 Comparison between mutual diffusion coefficients from different studies: D_{AB} of bitumen + pentane system from this work (■); from Zhang and Shaw 2007 (●).

Measurements from the current study have smaller errors over broad composition ranges. Thus, the upgrades to the apparatus were effective. The errors could be further reduced by performing measurements at different global compositions, e.g., at w = 0.2, w = 0.9. The error is smallest around the global composition where the spatial and time gradients are largest.

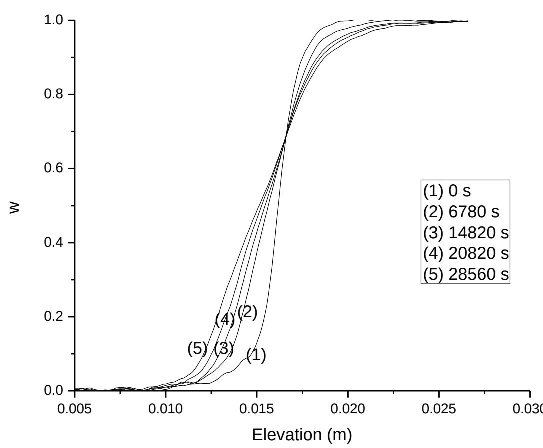
5.1.2 Atmospheric Residue + Pentane

Intensity profiles and pentane concentration profiles are shown in Figure 5-4 (a) and (b), respectively, for vacuum residue + pentane. The mutual diffusion coefficients are presented in Table 5-2. Coefficients appearing in equation 3-3 for this case are α=2.29*10^{-11} m^2/s, β=5.59*10^{-12} m^2/s, ε=8.58*10^{-12} m^2/s and γ =

$6.90*10^{-11}$ m^2/s. These coefficients were regressed from composition profiles in the range 60wt % to 80wt %.



(a)



(b)

Figure 5-4 Free diffusion of the 30 mL Atmospheric residue + 70 mL pentane system. (a) X-ray intensity profiles at different times, (b) pentane mass fraction profiles.

Table 5-2 Mutual diffusion coefficients: pentane + atmospheric residue

Pentane mass fraction	Diffusion Coefficient (m^2/s)	Error (m^2/s)
0.66	4.4E-11	8E-12
0.67	4.5E-11	3E-12
0.68	4.7E-11	6E-13
0.69	4.8E-11	8E-13
0.71	5.0E-11	7E-13
0.72	5.1E-11	6E-13
0.73	5.2E-11	2E-12
0.75	5.4E-11	8E-12
0.76	5.5E-11	1E-11
0.77	5.7E-11	2E-11

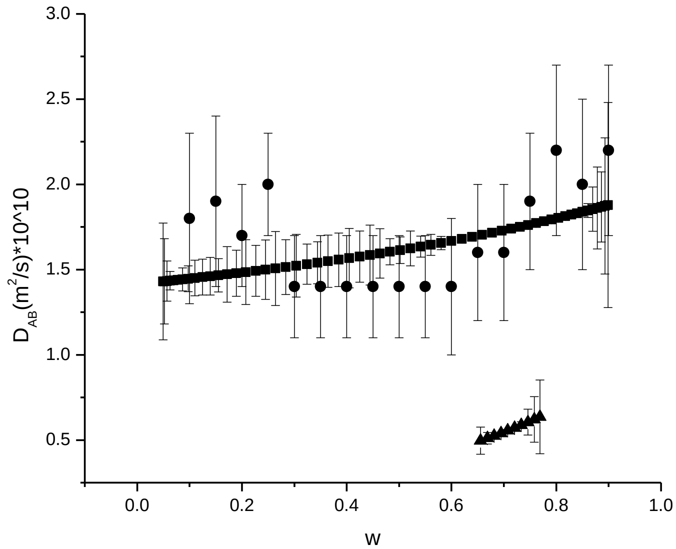


Figure 5-5 Comparison between atmospheric residue and bitumen. Diffusion coefficients of bitumen + pentane (■); the same parameter as reported by Zhang and Shaw 2007 (●); diffusion coefficients of atmospheric residue + pentane (▲).

The high solids content in the atmospheric residue relative to the bitumen with a solids content of almost 50% [21] resulted in a one-order-of-magnitude smaller mutual diffusion coefficient, as seen in Figure 5-5. Data are not yet available but the solids content exceeds 50 %. As the absolute error of the mutual diffusion coefficient is independent of the value of the diffusion coefficient, meaningful measurements could only be made over a narrow range of composition that was close to the mixture composition. The composition data for atmospheric residue is fit over the range of 60wt % to 80wt %. These measurements could not have been performed with the previous data acquisition system.

For the heavy oil and bitumen reservoirs in Canada, the hydrocarbon resource is stratified — with higher molar mass and more asphaltene-rich organic material near the bottom [22]. Given the large difference in mutual diffusion coefficients between bitumen and atmospheric residue, proposed penetrants such as propane, methane, CO_2, etc. are likely to move horizontally or upward from the point of injection rather than downward into reservoirs. This result has numerous implications for process selection and process design. Further, such reservoirs are normally cool — around 8°C. Thus, the diffusion coefficients are likely to be smaller compared to the values reported here and the impacts of solids more pronounced, unless the reservoirs are heated prior to or concurrent with penetrant injection.

5.2 Forced Mass Transfer

For these experiments, the samples were prepared in the same manner as for the free diffusion experiments. However, a mixer was used to keep the pentane rich phase well-mixed.

5.2.1 Well-Mixed Test Results

The composition of the pentane-rich phase was recorded at elevations above and below the stirrer as shown in Figure 4-8. The compositions are reported in Table 5-3 and in Figure 5-6 for three sampling times. Variations are within 0.15 wt % of the means for all cases and reflect measurement errors rather than spatial variations. The pentane rich phase was well mixed.

Table 5-3 Well-mixed test results. Reported average concentration for this case: 94%, 95% and 97.5%

Data Point Elevation from the interface (mm)	W at t = 3 hr	W at t = 1.1 hr	W at t = 0.3 hr
5	94.1%	95.2%	97.3%
10	94.0%	95.0%	97.6%
15	94.1%	94.9%	97.5%
30	93.9%	94.9%	97.5%
32	93.9%	95.0%	97.6%
34	94.0%	95.1%	97.6%
36	93.9%	95.1%	97.3%

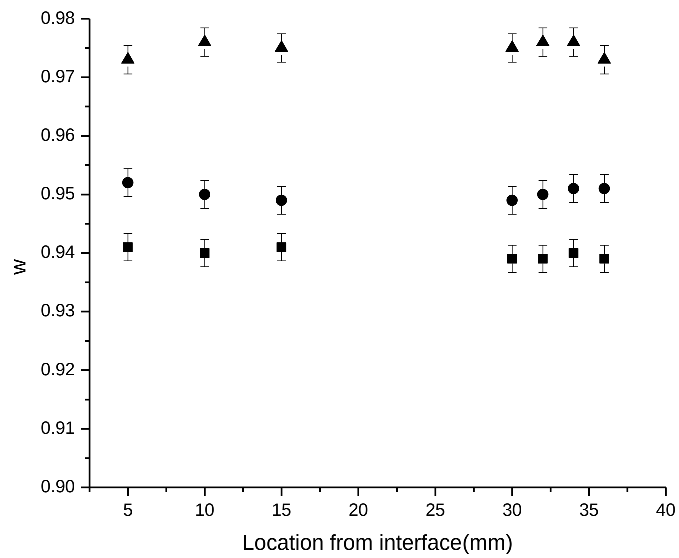


Figure 5-6 Well-mixed test result. Pentane concentration at different elevations from the interface: ▲ t = 0.3 hr; ● t = 1.1 hr; ■ t = 3 hr.

5.2.2 Comparison Between Different Monitoring Techniques

As mentioned in Chapter 3, two different techniques were used to measure mass transfer rates:

1- Monitoring the heavy oil concentration in solvent phase

2- Monitoring the solvent-heavy oil interface elevation

This section compares results obtained from these two methods and allowing for the uncertainty of whether bitumen or atmospheric residue is soluble in pentane. Four mixing rates were used: 2.31, 5.16, 6.9, and 9.75 Hz. Values of mass transfer coefficients are tabulated in Table **5-4**, Table **5-5**, Table **5-6**, Table **5-7**, Table **5-8** and Table 5-9 and are presented in Figure 5-7, Figure 5-8, Figure 5-9, Figure 5-10, Figure 5-11 and Figure 5-12, respectively. As one can readily observe in the graphs and tables, the measurement method and assumptions (regarding the solubility of bitumen or atmospheric residue in pentane) have little impact on mass transfer coefficient values — within experimental errors.

Table 5-4 Comparison between K_{int} (calculated from monitoring the interface) and K_{bulk} (calculated from monitoring the bulk) employing two different dependency of *w* on mass trasnfer rate, bitumen + pentane, mixing rate = 2.31 Hz.

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.98	1.0E-06	3E-07	2.4E-06	6E-07	9.8E-07	3E-07	2.4E-06	4E-07	1.7E-06
0.97	7.5E-07	2E-07	8.1E-07	1E-07	7.4E-07	2E-07	8.0E-07	2E-07	7.8E-07
0.95	3.0E-07	1E-07	4.20E-07	7E-08	2.9E-07	1E-07	4.1E-07	8E-08	3.6E-07
0.94	5.6E-08	2E-08	2.1E-07	5E-08	5.4E-08	2E-08	2.0E-07	4E-08	1.3E-07
0.91	7.6E-08	3E-08	1.9E-07	5E-08	7.0E-08	2E-08	1.8E-07	3E-08	1.3E-07

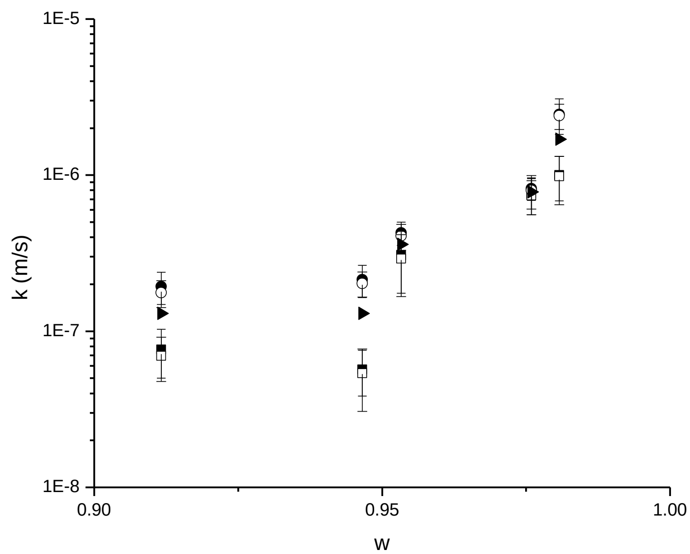


Figure 5-7 Comparison between ●○ K_{int} (calculated from monitoring the interface) $1/w^3$ and $1/w^2$ dependency, ■□K_{bulk} (calculated from monitoring the bulk) $1/w^3$ and $1/w^2$ dependency, ►Average Value, bitumen + pentane, mixing rate = 2.31 Hz

Table 5-5 Comparison between K_{int} and K_{bulk}, employing two different dependency of *w* on mass trasnfer rate, bitumen + pentane, mixing rate = 5.16 Hz

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.988	5.1E-05	3E-06	2.6E-05	3E-06	5.1E-05	3E-06	2.6E-05	5E-06	3.9E-05
0.982	4.8E-05	3E-06	2.6E-05	4E-06	4.7E-05	5E-06	2.5E-05	5E-06	3.7E-05
0.977	3.9E-05	2E-06	2.6E-05	5E-06	3.8E-05	3E-06	2.5E-05	3E-06	3.2E-05
0.973	3.9E-05	3E-06	2.3E-05	4E-06	3.8E-05	2E-06	2.2E-05	3E-06	3.1E-05
0.968	3.8E-05	2E-06	1.1E-05	1E-06	3.7E-05	2E-06	1.1E-05	2E-06	2.4E-05
0.964	3.2E-06	2E-07	5.7E-06	9E-07	3.1E-06	3E-07	5.5E-06	6E-07	4.4E-06
0.960	6.9E-06	6E-07	8.6E-06	9E-07	6.7E-06	3E-07	8.2E-06	1E-06	7.6E-06
0.957	2.3E-05	1E-06	1.1E-05	2E-06	2.2E-05	2E-06	1.1E-05	2E-06	1.7E-05
0.955	2.5E-05	2E-06	1.1E-05	2E-06	2.4E-05	2E-06	1.1E-05	2E-06	1.8E-05
0.952	7.8E-06	6E-07	9.5E-06	1E-06	7.5E-06	7E-07	9.0E-06	2E-06	8.5E-06
0.949	5.4E-06	4E-07	7.1E-06	1E-06	5.2E-06	3E-07	6.7E-06	1E-06	6.1E-06
0.946	5.1E-06	3E-07	8.5E-06	1E-06	4.9E-06	4E-07	8.1E-06	1E-06	6.7E-06
0.940	2.2E-05	2E-06	1.1E-05	2E-06	2.1E-05	1E-06	1.1E-05	2E-06	1.6E-05
0.936	8.6E-06	6E-07	8.5E-06	9E-07	8.1E-06	8E-07	7.9E-06	2E-06	8.3E-06
0.933	5.9E-06	6E-07	6.6E-06	9E-07	5.5E-06	5E-07	6.2E-06	1E-06	6.1E-06
0.928	9.2E-06	5E-07	5.6E-06	9E-07	8.5E-06	6E-07	5.2E-06	8E-07	7.1E-06
0.926	4.0E-06	2E-07	3.3E-06	4E-07	3.7E-06	2E-07	3.0E-06	6E-07	3.5E-06
0.924	2.0E-06	1E-07	2.1E-06	4E-07	1.9E-06	2E-07	1.9E-06	4E-07	2.0E-06
0.925	6.5E-07	3E-08	9.4E-07	1E-07	6.0E-07	3E-08	8.7E-07	1E-07	7.7E-07
0.924	6.5E-07	4E-08	8.8E-07	1E-07	6.0E-07	4E-08	8.1E-07	1E-07	7.4E-07

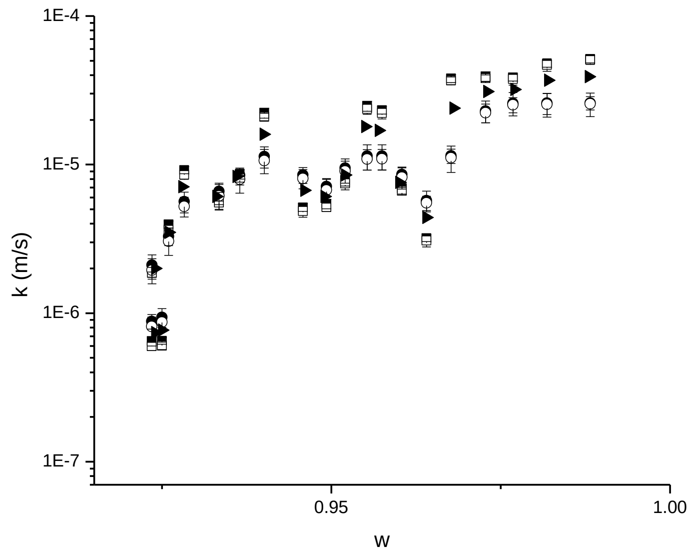


Figure 5-8 Comparison between ● ○ K_{int} 1/w^3 and 1/w^2 dependency, ■ □K_{bulk} 1/w^3 and 1/w^2 dependency, ►Average Value, bitumen + pentane, mixing rate = 5.16 Hz

Table 5-6 Comparison between K_{int} and $K_{bulk,}$ employing two different dependency of *w* on mass trasnfer rate, bitumen + pentane, mixing rate = 6.9 Hz

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.999	9.0E-05	7E-06	7.0E-05	9E-07	9.0E-05	6E-06	7.0E-05	1E-06	8.0E-05
0.993	9.5E-05	7E-06	6.4E-05	7E-07	9.4E-05	8E-06	6.3E-05	8E-07	7.9E-05
0.987	9.2E-05	8E-06	5.8E-05	1E-06	9.0E-05	7E-06	5.7E-05	8E-07	7.4E-05
0.982	9.3E-05	4E-06	5.8E-05	1E-06	9.2E-05	4E-06	5.7E-05	1E-06	7.5E-05
0.976	9.5E-05	5E-06	5.7E-05	1E-06	9.3E-05	5E-06	5.6E-05	7E-07	7.5E-05
0.954	9.5E-05	5E-06	5.1E-05	5E-07	9.1E-05	4E-06	4.9E-05	8E-07	7.2E-05
0.948	3.0E-05	2E-06	5.7E-05	9E-07	2.9E-05	2E-06	5.4E-05	7E-07	4.3E-05
0.943	7.0E-05	3E-06	5.1E-05	6E-07	6.6E-05	5E-06	4.8E-05	6E-07	5.9E-05
0.937	4.0E-05	2E-06	5.1E-05	5E-07	3.8E-05	3E-06	4.8E-05	7E-07	4.4E-05
0.932	9.2E-05	5E-06	5.1E-05	8E-07	8.6E-05	4E-06	4.7E-05	5E-07	6.9E-05
0.928	9.1E-05	7E-06	4.5E-05	6E-07	8.4E-05	7E-06	4.2E-05	8E-07	6.6E-05
0.923	1.0E-04	9E-06	5.1E-05	9E-07	9.2E-05	4E-06	4.7E-05	6E-07	7.3E-05
0.918	7.0E-05	5E-06	5.1E-05	7E-07	6.4E-05	3E-06	4.6E-05	8E-07	5.8E-05
0.913	5.8E-05	5E-06	4.5E-05	6E-07	5.3E-05	3E-06	4.1E-05	7E-07	4.9E-05
0.909	5.1E-05	3E-06	3.9E-05	8E-07	4.6E-05	3E-06	3.6E-05	4E-07	4.3E-05
0.903	3.0E-05	2E-06	3.9E-05	7E-07	2.7E-05	1E-06	3.5E-05	4E-07	3.3E-05
0.899	4.5E-05	2E-06	3.9E-05	6E-07	4.0E-05	2E-06	3.5E-05	6E-07	4.0E-05
0.896	7.2E-05	4E-06	3.9E-05	6E-07	6.5E-05	4E-06	3.5E-05	4E-07	5.3E-05
0.891	5.0E-05	3E-06	4.4E-05	7E-07	4.5E-05	2E-06	4.0E-05	8E-07	4.5E-05
0.887	4.6E-05	4E-06	3.3E-05	6E-07	4.0E-05	2E-06	2.9E-05	5E-07	3.7E-05

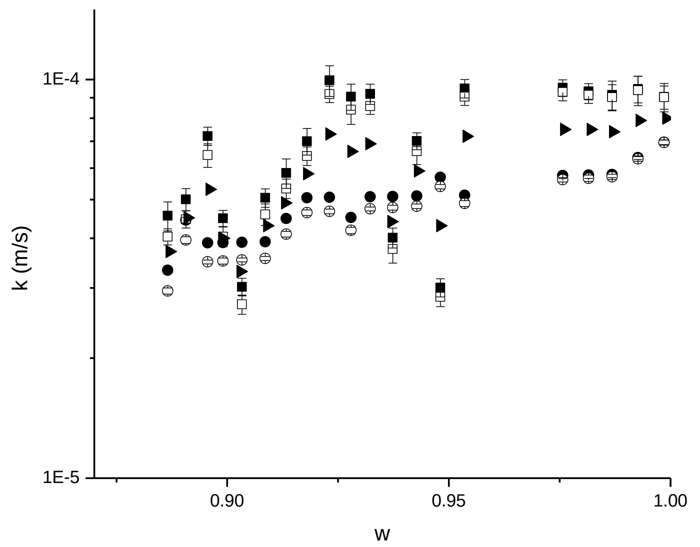


Figure 5-9 Comparison between ● ○ K_{int} $1/w^3$ and $1/w^2$ dependency, ■ □K_{bulk} $1/w^3$ and $1/w^2$ dependency, ►Average Value, bitumen + pentane, mixing rate = 6.9 Hz

Table 5-7 Comparison between K_{int} and $K_{bulk,}$ employing two different dependency of *w* on mass trasnfer rate, bitumen + pentane, mixing rate = 9.75 Hz

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.985	9.8E-05	1E-06	8.7E-05	5E-06	9.6E-05	2E-06	8.5E-05	6E-06	9.2E-05
0.975	1.2E-04	2E-06	1.3E-04	1E-05	1.2E-04	2E-06	1.3E-04	7E-06	1.3E-04
0.956	1.0E-04	1E-06	1.2E-04	5E-06	9.7E-05	2E-06	1.2E-04	5E-06	1.1E-04
0.947	9.9E-05	2E-06	7.7E-05	5E-06	9.4E-05	2E-06	7.3E-05	5E-06	8.6E-05
0.939	1.1E-04	2E-06	1.3E-04	9E-06	1.0E-04	2E-06	1.2E-04	6E-06	1.2E-04
0.930	1.1E-04	2E-06	1.1E-04	5E-06	1.1E-04	2E-06	1.1E-04	4E-06	1.1E-04
0.920	1.2E-04	2E-06	1.0E-04	6E-06	1.1E-04	2E-06	9.4E-05	4E-06	1.1E-04
0.912	1.0E-04	1E-06	1.1E-04	6E-06	9.5E-05	2E-06	1.0E-04	5E-06	1.0E-04
0.905	8.7E-05	2E-06	8.4E-05	4E-06	7.9E-05	9E-07	7.6E-05	3E-06	8.2E-05
0.985	9.8E-05	1E-06	8.7E-05	5E-06	9.6E-05	2E-06	8.5E-05	6E-06	9.2E-05
0.975	1.2E-04	2E-06	1.3E-04	1E-05	1.2E-04	2E-06	1.3E-04	7E-06	1.3E-04
0.956	1.0E-04	1E-06	1.2E-04	5E-06	9.7E-05	2E-06	1.2E-04	5E-06	1.1E-04
0.947	9.9E-05	2E-06	7.7E-05	5E-06	9.4E-05	2E-06	7.3E-05	5E-06	8.6E-05
0.939	1.1E-04	2E-06	1.3E-04	9E-06	1.0E-04	2E-06	1.2E-04	6E-06	1.2E-04
0.930	1.1E-04	2E-06	1.1E-04	5E-06	1.1E-04	2E-06	1.1E-04	4E-06	1.1E-04
0.920	1.2E-04	2E-06	1.0E-04	6E-06	1.1E-04	2E-06	9.4E-05	4E-06	1.1E-04
0.912	1.0E-04	1E-06	1.1E-04	6E-06	9.5E-05	2E-06	1.0E-04	5E-06	1.0E-04
0.905	8.7E-05	2E-06	8.4E-05	4E-06	7.9E-05	9E-07	7.6E-05	3E-06	8.2E-05

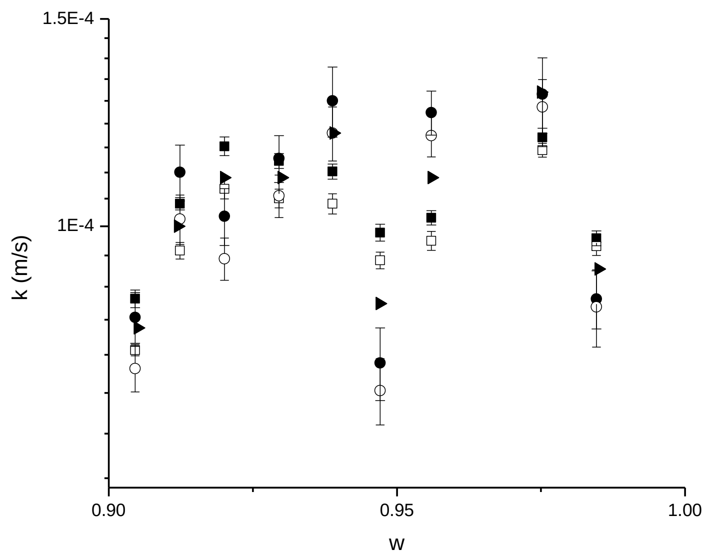


Figure 5-10 Comparison between ● ○ K_{int} $1/w^3$ and $1/w^2$ dependency, ■ □K_{bulk} $1/w^3$ and $1/w^2$ dependency, ►Average Value, bitumen + pentane, mixing rate = 9.75 Hz

Table 5-8 Comparison between K_{int} and K_{bulk}, employing two different dependency of *w* on mass trasnfer rate, Atmospheric Residue + pentane, mixing rate = 2.31 Hz

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.994	3.0E-07	7E-08	4.6E-07	1E-07	3.0E-07	1E-07	4.5E-07	1E-07	3.8E-07
0.989	3.8E-07	1E-07	3.9E-07	1E-07	3.7E-07	1E-07	3.8E-07	1E-07	3.8E-07
0.985	3.3E-07	7E-08	2.9E-07	8E-08	3.3E-07	1E-07	2.9E-07	7E-08	3.1E-07
0.980	1.4E-07	4E-08	1.3E-07	4E-08	1.3E-07	5E-08	1.3E-07	4E-08	1.3E-07
0.969	1.3E-07	4E-08	1.1E-07	3E-08	1.2E-07	5E-08	1.0E-07	2E-08	1.2E-07
0.962	7.5E-08	2E-08	8.5E-08	2E-08	7.2E-08	3E-08	8.2E-08	2E-08	7.9E-08
0.956	5.6E-08	2E-08	6.7E-08	2E-08	5.3E-08	2E-08	6.4E-08	1E-08	6.0E-08
0.950	4.2E-08	1E-08	2.6E-08	6E-09	3.9E-08	1E-08	2.5E-08	4E-09	3.3E-08
0.994	3.0E-07	7E-08	4.6E-07	1E-07	3.0E-07	1E-07	4.5E-07	1E-07	3.8E-07
0.989	3.8E-07	1E-07	3.9E-07	1E-07	3.7E-07	1E-07	3.8E-07	1E-07	3.8E-07
0.985	3.3E-07	7E-08	2.9E-07	8E-08	3.3E-07	1E-07	2.9E-07	7E-08	3.1E-07
0.980	1.4E-07	4E-08	1.3E-07	4E-08	1.3E-07	5E-08	1.3E-07	4E-08	1.3E-07
0.969	1.3E-07	4E-08	1.1E-07	3E-08	1.2E-07	5E-08	1.0E-07	2E-08	1.2E-07
0.962	7.5E-08	2E-08	8.5E-08	2E-08	7.2E-08	3E-08	8.2E-08	2E-08	7.9E-08
0.956	5.6E-08	2E-08	6.7E-08	2E-08	5.3E-08	2E-08	6.4E-08	1E-08	6.0E-08
0.950	4.2E-08	1E-08	2.6E-08	6E-09	3.9E-08	1E-08	2.5E-08	4E-09	3.3E-08

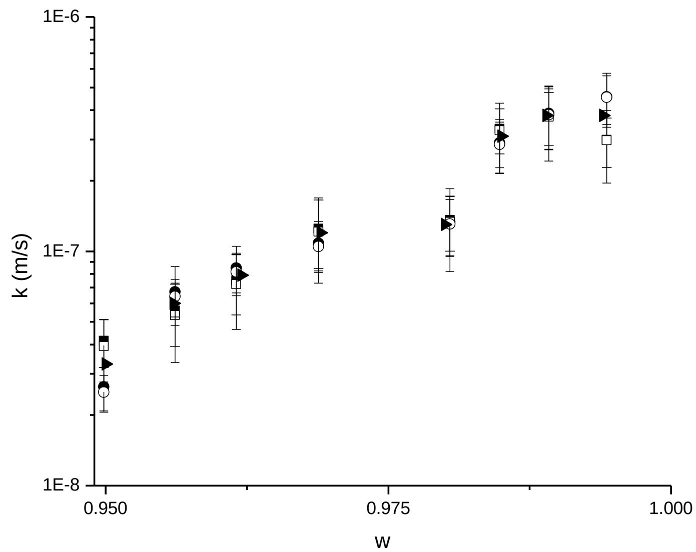


Figure 5-11 Comparison between ● ○ K_{int} $1/w^3$ and $1/w^2$ dependency, ■ □K_{bulk} $1/w^3$ and $1/w^2$ dependency, ►Average Value, Atmospheric Residue + pentane, mixing rate = 2.31 Hz

Table 5-9 Comparison between K_{int} and K_{bulk}, employing two different dependency of *w* on mass trasnfer rate, Atmospheric Residue + pentane, mixing rate = 9.75 Hz

	$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^3}\frac{\partial w_2}{\partial t}\right]$				$K=\left[\frac{M_2}{A\rho_1}\right]\left[\frac{-1}{w_2^2}\frac{\partial w_2}{\partial t}\right]$				
w	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	K_{bulk}(m/s)	Error	K_{int}(m/s)	Error	Average
0.963	5.3E-06	8E-07	7.5E-06	1E-06	5.1E-06	1E-06	7.2E-06	1E-06	6.3E-06
0.956	4.8E-06	8E-07	6.8E-06	9E-07	4.6E-06	7E-07	6.5E-06	9E-07	5.7E-06
0.948	9.2E-06	2E-06	7.9E-06	1E-06	8.7E-06	1E-06	7.5E-06	9E-07	8.3E-06
0.939	7.9E-06	1E-06	8.2E-06	1E-06	7.4E-06	1E-06	7.7E-06	1E-06	7.8E-06
0.931	1.5E-05	2E-06	8.9E-06	1E-06	1.4E-05	2E-06	8.3E-06	9E-07	1.2E-05
0.921	2.3E-05	4E-06	1.1E-05	1E-06	2.2E-05	2E-06	9.8E-06	2E-06	1.6E-05
0.910	2.3E-05	3E-06	1.2E-05	2E-06	2.1E-05	3E-06	1.1E-05	1E-06	1.7E-05
0.899	2.6E-05	3E-06	1.1E-05	1E-06	2.3E-05	5E-06	9.7E-06	1E-06	1.7E-05
0.890	6.4E-06	1E-06	9.9E-06	2E-06	5.7E-06	9E-07	8.8E-06	1E-06	7.7E-06
0.882	1.1E-05	2E-06	1.0E-05	2E-06	9.9E-06	2E-06	9.1E-06	1E-06	1.0E-05
0.872	3.4E-05	3E-06	1.1E-05	2E-06	2.9E-05	4E-06	9.3E-06	1E-06	2.1E-05
0.864	1.4E-05	2E-06	1.0E-05	2E-06	1.2E-05	2E-06	9.0E-06	2E-06	1.1E-05
0.855	1.1E-04	2E-05	1.1E-05	2E-06	9.2E-05	2E-05	9.2E-06	2E-06	5.6E-05

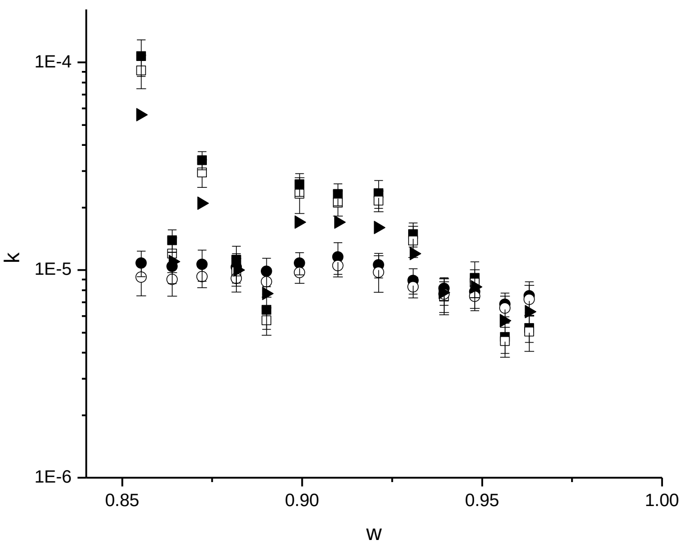
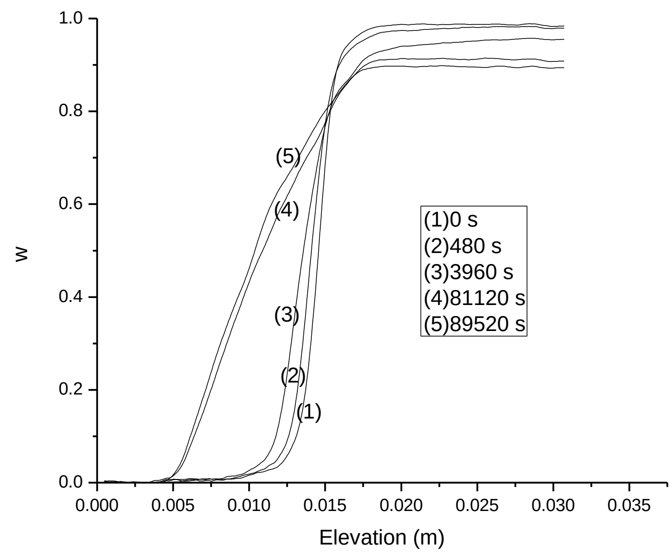


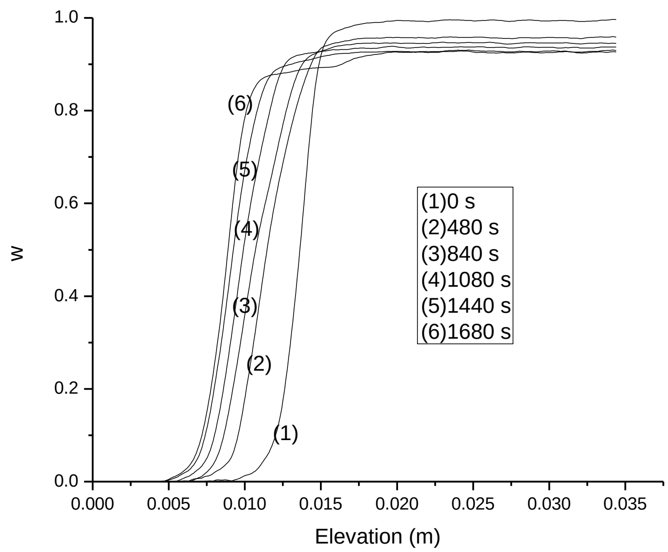
Figure 5-12 Comparison between ● ○ K_{int} $1/w^3$ and $1/w^2$ dependency, ■ □K_{bulk} $1/w^3$ and $1/w^2$ dependency, ►Average Value, Atmospheric Residue + pentane, mixing rate = 9.75 Hz

5.2.3 Mass Transfer Rate at the Bitumen + Pentane Interface

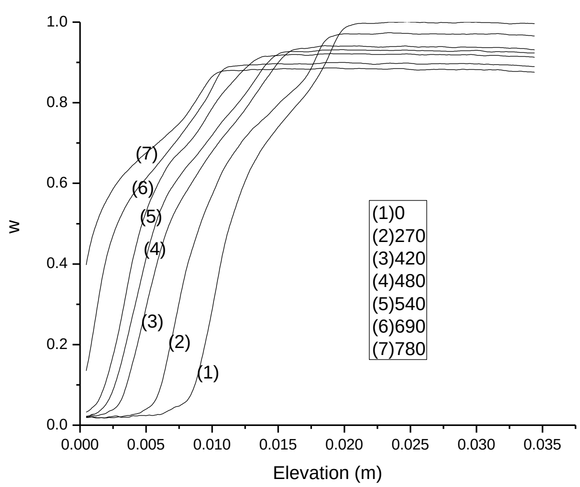
The impeller distance from the initial interface was fixed at 2.2 cm. The concentration profiles are shown in Figure 5-13. As there is little difference among the various measurements and data analysis approaches, average mass transfer coefficients from Table 5-4, Table 5-5, Table 5-6 and Table 5-7 are shown in Figure 5-14. At high mixing rates (9.75 Hz and 6.9 Hz), the mass transfer rate was independent of pentane concentration. However, at low mixing rates, the mass transfer coefficient decreased sharply with composition. Composition and the distance of the impeller from the interface are joint variables. At 2.31 Hz, the mass transfer rate dropped sharply to the diffusion limit once the interface retreated from 2 to 2.5 cm. At 5.16 Hz, the mass transfer rate dropped sharply once the interface retreated from 2 to 2.8 cm. At higher impeller speeds, this effect was not observed even at an impeller-interface distance of 3.5 cm.



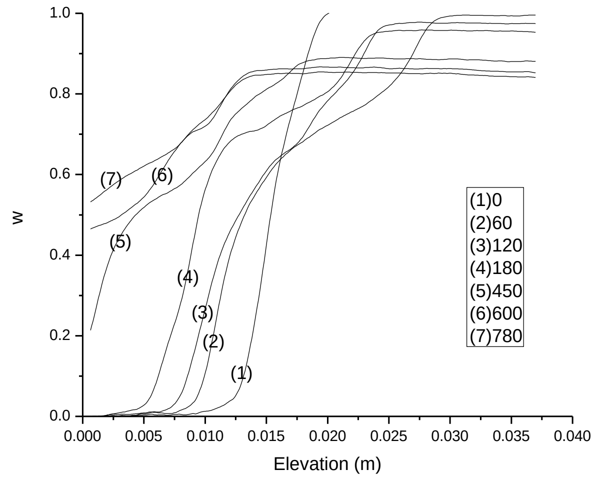
(a)


w
Elevation (m)
(1)0 s
(2)480 s
(3)840 s
(4)1080 s
(5)1440 s
(6)1680 s

(b)

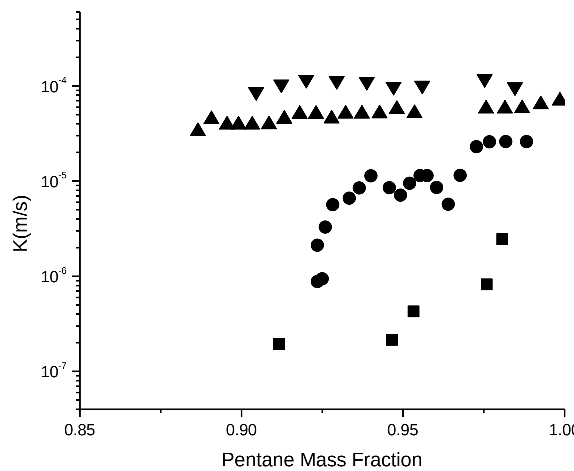

w
Elevation (m)
(1)0
(2)270
(3)420
(4)480
(5)540
(6)690
(7)780

(c)

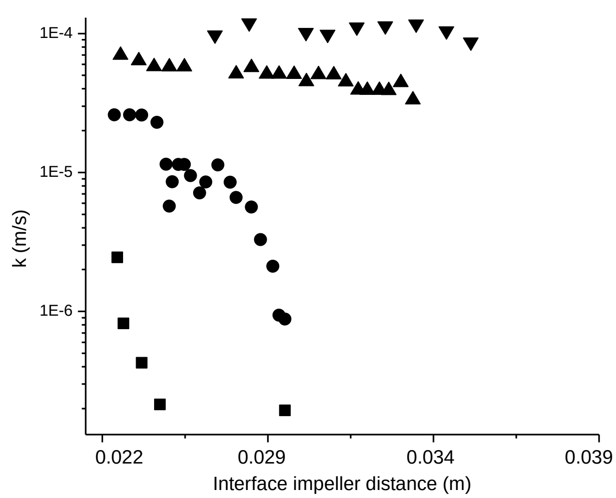


(d)

Figure 5-13 Pentane concentration profiles at different mixing rates for the 80 mL pentane + 20 mL bitumen system: (a) 2.31 Hz, (b) 5.16 Hz, (c) 6.9 Hz, (d) 9.75 Hz.



(a)

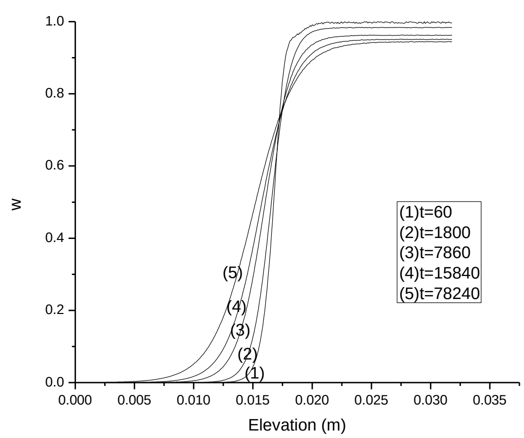


(b)

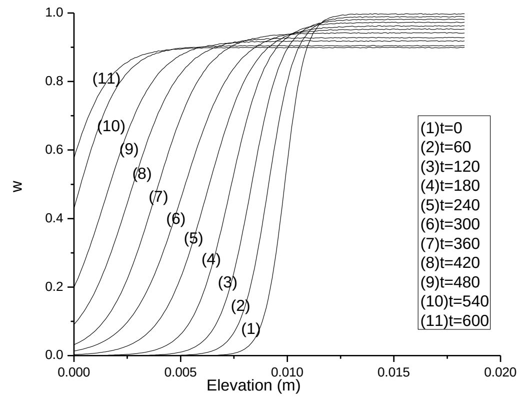
Figure 5-14 Mass transfer at different mixing rates: ■2.31 Hz ●5.16 Hz ▲6.9 Hz▼9.75 Hz, for bitumen + pentane. (a) Mass transfer coefficient vs wt % pentane, (b) mass transfer rate vs interface impeller distance.

5.2.4 Mass Transfer Rate at Atmospheric Residue + Pentane Interface at Different Shear Rates

The initial impeller distance from the interface was fixed at 2.2 cm. The concentration profiles are shown in Figure 5-15. As there is little difference among the various measurement and data analysis approaches, average mass transfer coefficients from Table 5-8 and Table 5-9 are shown in Figure 5-17. At 9.75 Hz, the mass transfer rate was independent of pentane concentration. However, at low mixing rates, the mass transfer coefficient decreased sharply with composition. Composition and the distance between the impeller and the interface are joint variables. At 2.31 Hz, the mass transfer rate dropped sharply to the diffusion limit once the interface retreated from 1.5 to 2 cm. At 9.75 Hz, this effect was not observed even for impeller-interface distances of 3.5 cm.

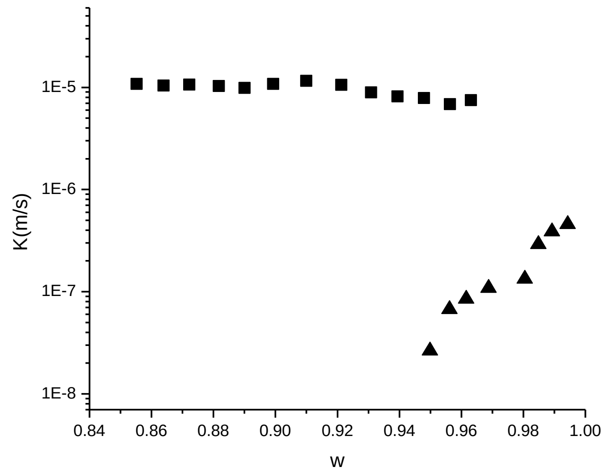


(a)

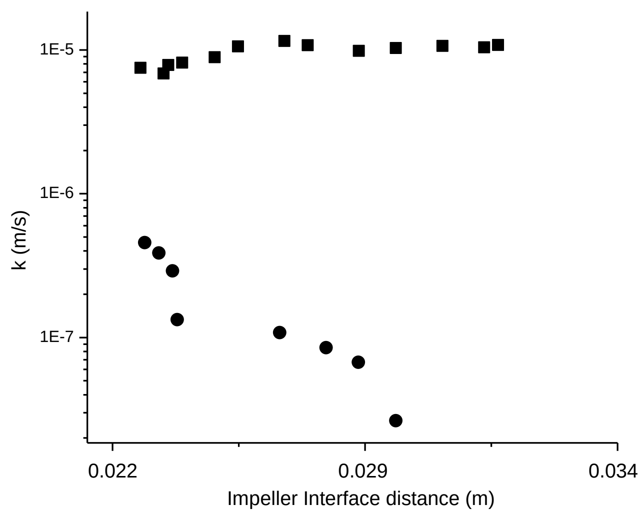


(b)

Figure 5-16 Pentane concentration profiles at different mixing rates for the 80 mL pentane + 20 mL Atmospheric Residue system. Impeller speeds were (a) 2.31 Hz, (b) 9.75 Hz.



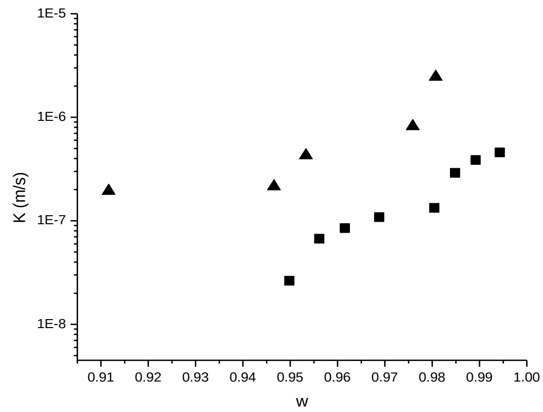
(a)



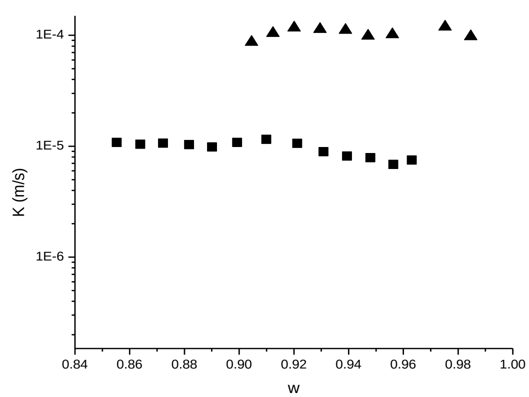
(b)

Figure 5-17 (a) Mass transfer rates at different mixing speeds: ■ 9.75 Hz ● 2.31 Hz, for the atmospheric residue + pentane system; (b) mass transfer rate vs distance of the interface from the stirrer.

5.2.5 Comparison between Atmospheric Residue and Bitumen



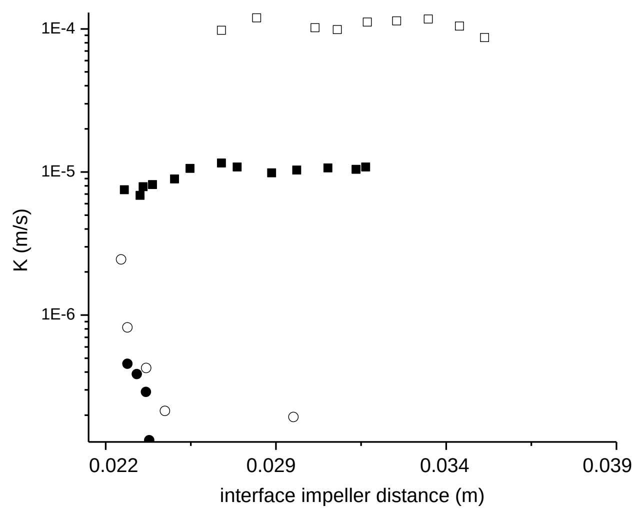
(a)

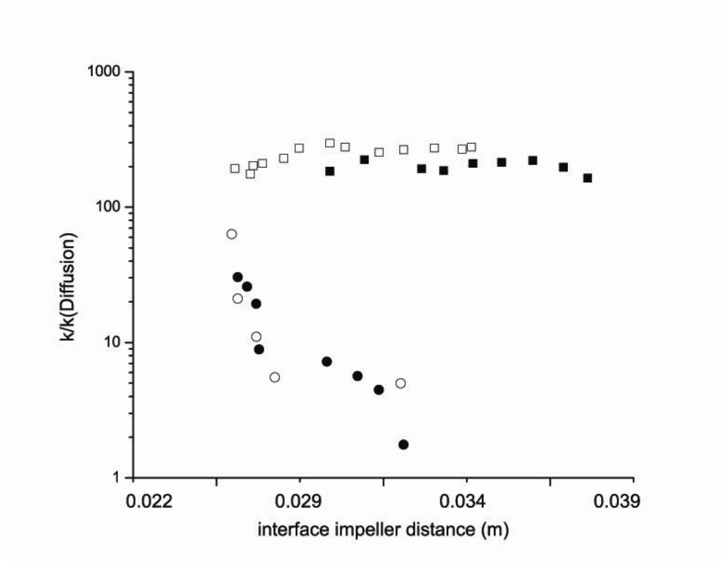


(b)

Figure 5-18 Comparison between bitumen and atmospheric residue mass transfer rates:

■Atmospheric Residue ▲ Bitumen. (a) Mixing speed = 2.31 Hz, (b)mixing speed = 9.75 Hz.





(a)

(b)

Figure 5-19 Comparison between mass transfer rate of bitumen and atmospheric residue at different distances from the interface, ■ Atmospheric residue at mixing rate of 9.75 Hz, ● Atmospheric residue at mixing rate of 2.31 Hz ,○ Bitumen at mixing rate of 9.75 Hz □ Bitumen at mixing rate of 2.31 Hz (a) mass transfer rate (b) normalized mass transfer rate

Figure 5-18 and Figure 5-19 indicates that atmospheric residue in both cases showed a one-order-of-magnitude smaller mass transfer rate compared to bitumen. This is the direct consequence of higher solids content in the atmospheric residue at room temperature, which made it more difficult for pentane to penetrate into the atmospheric residue compared to the case for bitumen. Also one can observe that both atmospheric residue and bitumen follow the same pattern in normalized graph. This gives the ability to predict the heavy oils behaviour independent of its nature.

5.2.6 Comparison with Similar Geometries in the Literature

This section compares our results to available data in the literature for systems with similar geometries. As can be seen in Figure 5-20, for every case that was studied, the mass transfer rate approached some asymptotic (i.e. plateau) value beyond a certain mixing speed. This suggests a shift in the mass transfer resistance from the hydrodynamic regime to some other rate-determining mechanism (e.g. reaction kinetics).

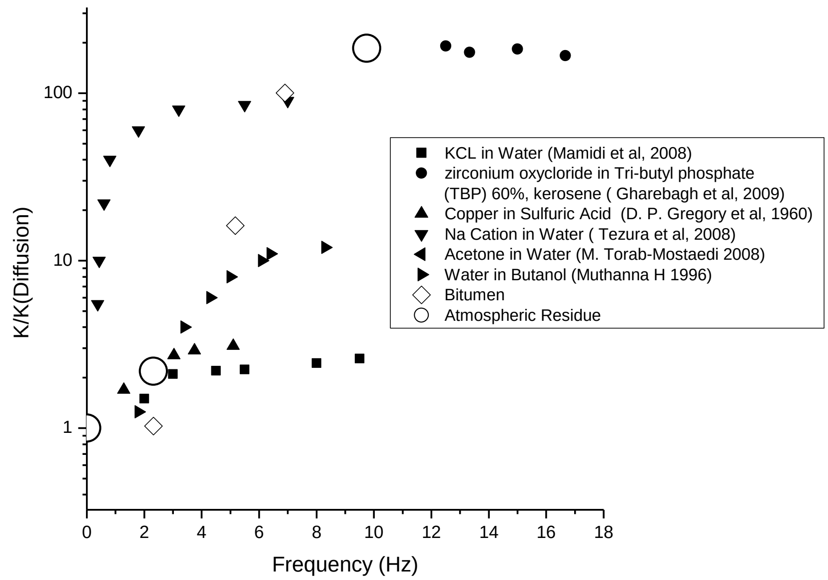


Figure 5-20 Comparison with previous studies involving similar geometries.

5.2.7 Comparison with Theory

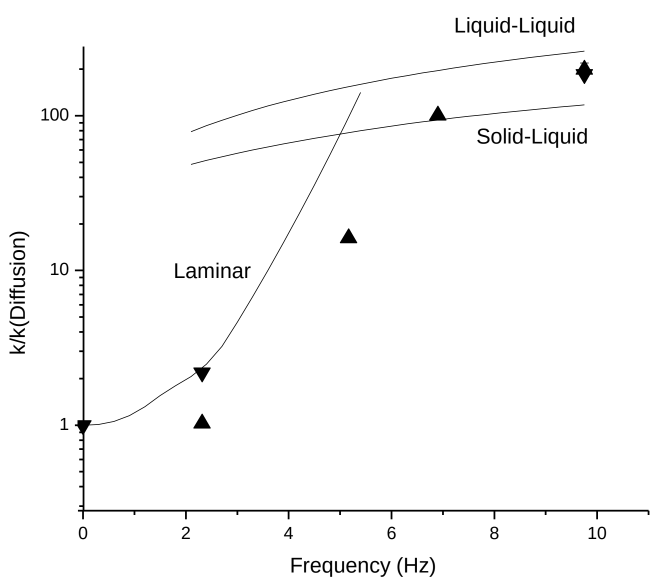


Figure 5-21 Comparison of mass transfer rates at different mixing rates for bitumen, atmospheric residue, and based on theory. Pentane concentration = 96%; impeller-interface distance = 0.022m. ▼ Bitumen, ▲ Atmospheric residue, - Theory [20], Equation 3-14

Laminar region, Equation 3-15 Solid-liquid turbulent region, Equation 3-16 liquid-liquid turbulent region.

According to theory, in the laminar and transition zones, hydrodynamics of the solvent control the mass transfer rate. In the turbulent zone, the rate-limiting step becomes mass transfer in the bitumen phase, which is not impacted by the solvent mixing rate. As a result, the rate of mass transfer is almost constant. Equation 3-13, Equation 3-14 and Equation 3-15 have been used to calculate the liquid-liquid and liquid-solid mass transfer rates respectively. As the bitumen at room temperature is a mixture of solid and liquid, the mass transfer rate is intermediate between solid-liquid and liquid-liquid mass transfer rates in the turbulent zone.

Both atmospheric residue and bitumen follow the same pattern as mixing rate is increased. However, the transition between zones lags the theory. The mass transfer rate up to 2.31 Hz is still in the free diffusion range, which means to achieve higher mass transfer rates the operator should apply an intense shear field on the solvent-heavy oil interface. This lag reflects the impact of solid on the properties of the interface as the stirring rate is increased. The transition to diffusion control within the bitumen/atmospheric residue, is delayed. Boundary layers are thinner at a liquid-liquid interface than at a liquid-solid interface.

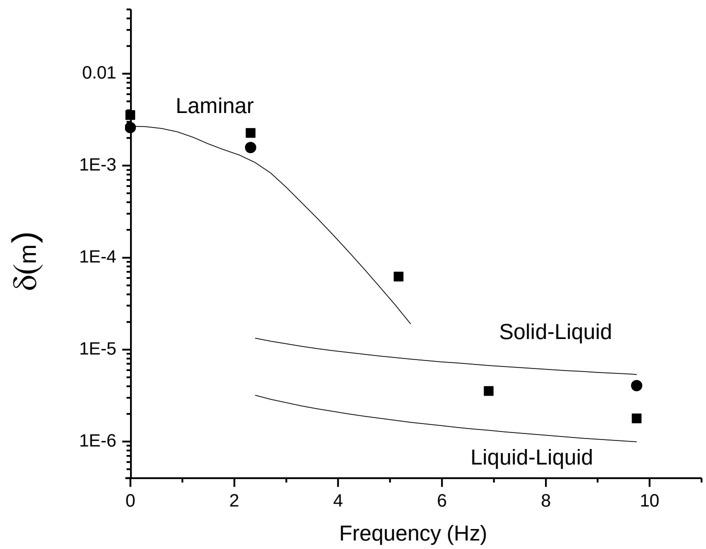


Figure 5-22 Comparison between bitumen, atmospheric residue and theoretical boundary layer thickness at different mixing speeds. Pentane concentration = 96%; impeller-interface distance = 0.022m. ■ Bitumen, ● Atmospheric residue, - Theory [20], Equation 3-13 Laminar region, Equation 3-14 Solid-liquid turbulent region, Equation 3-15 liquid-liquid turbulent region.

Figure 5-22 compares boundary layer thicknesses calculated by Equation 3-1. It shows that both atmospheric residue and bitumen follow the same pattern and the deviation from theory is again observed.

As the pentane penetrates into the heavy oil and dissolves it, a layer of solids remains on the interface (Figure 5-23).

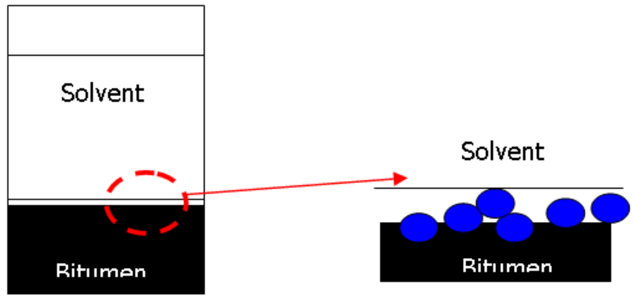


Figure 5-23 Solids deposition onto the interface.

Increasing the mixing speed will result in stronger shear field in the solvent phase; as a result, the solid layer thickness will decrease (Figure 5-24). This will explain the faster growth of mass transfer rate in heavy oil samples compared to theory.

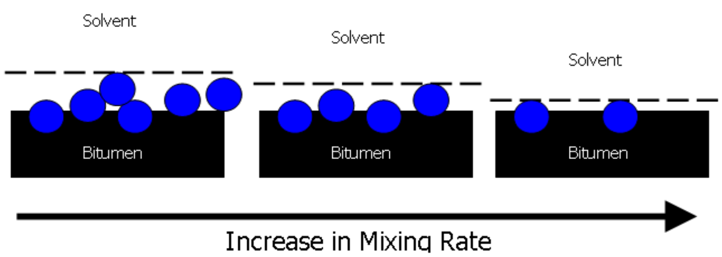


Figure 5-24 Shear effect on solid layer thickness.

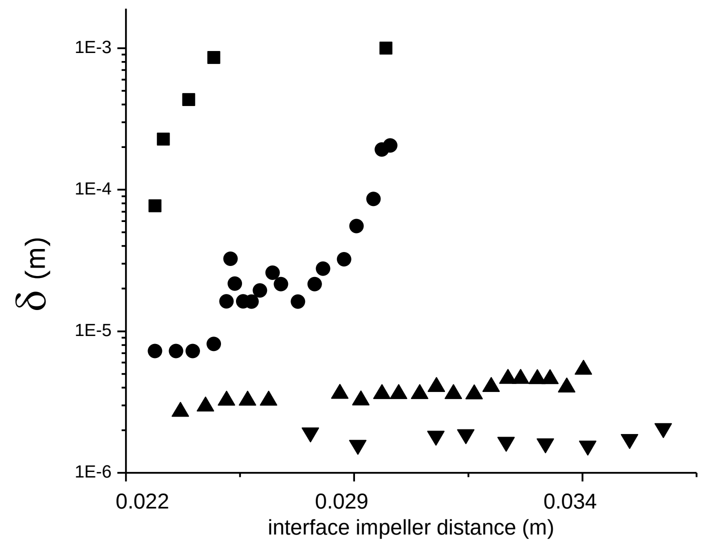


Figure 5-25 Boundary layer thickness vs impeller-interface distance: ■ 2.31 Hz, ● 5.16 Hz, ▲6.9 Hz, ▼ 9.75 Hz. Pentane + bitumen solution

Figure 5-25 shows the relationship between the interface-impeller distance and the boundary layer thickness. At high mixing speeds, the boundary layer thickness was not changing as the surface retreated (i.e. mixer had the same affectivity), but at low mixing speed the boundary layer thickness increased rapidly.

5.3 Case Study

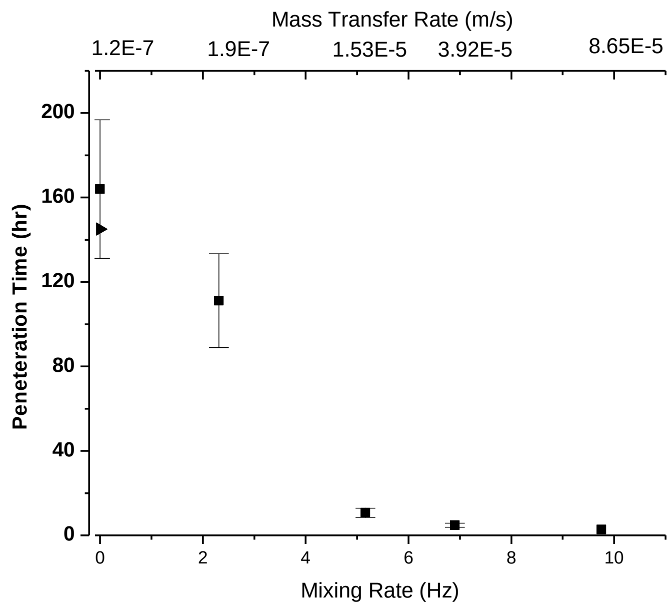


Figure 5-26 Time required to penetrate 1m into the bitumen phase: ■ this study, ► Nenniger 2008 (based on Equation 5-1).

Figure 5-26 presents the time required to penetrate 1m into bitumen with pentane at different mixing rates (mass transfer rates). The Figure also shows the time calculated by the correlation from Nenniger et al (Equation 5-1) for the same case. Note that this correlation is for diffusive mass transfer only.

Equation 5-1

$$k = 43\times10^{-3}\left(\frac{\mu}{P\phi}\right)^{-0.51}$$

Here, μ is the heavy oil viscosity (cp), P is the permeability (darcy), and Φ is the void fraction. To make the results from this study compatible with Nenniger's correlation, the parameters had been set to the following values:

$\Phi = 1$

$P = 5376$ darcy

$\mu = 400000$ cp [23]

The value $P = 5376$ is the maximum for permeability in Nenniger's correlation; this can be interpreted as invisible reservoir material (e.g. absence of sand in the oil sands).

In addition to correlation, by analysing Nenniger's raw images, the mass transfer rate of hexane into bitumen at an uncontrolled unknown temperature was also calculated. Figure 5-27 presents the results from this calculation.

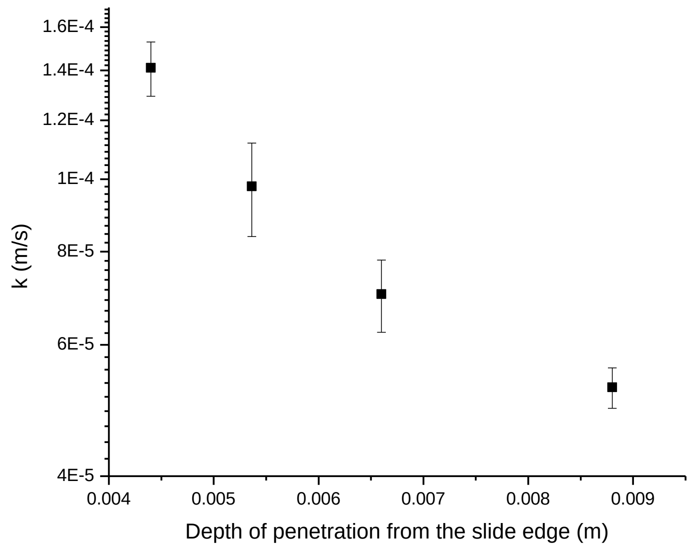


Figure 5-27 Mass transfer coefficient for hexane into bitumen: results derived directly from Nenniger's microscope images at an unknown temperature.

To obtain results from Nenniger's microscope images, the following assumptions were made:

1- No temperature change during the experiment

2- Homogenous temperature

3- Infinite fresh solvent resource (solvent bulk mole fraction = 1)

4- No edge effect, i.e., penetration is in one direction only.

Monitoring the oil-solvent interface leads to the mass transfer rate (Equation 3-8). Note that the mass transfer rate drops rapidly with boundary layer thickness.

Results from this study show strong agreement with Nenniger's correlation. Moreover, at low mixing rates, the time scale is on the order of days. As the mixing rate increases, however, this time scale drops sharply. The results also show that after a certain mixing rate, the time is almost constant, and the rate of dissolution is independent of mixing rate. A significant decrease in penetration times is also expected with increasing temperature.

6. Conclusions

The main motivation behind this research was the need to accurately measure mutual diffusion and forced mass transfer at heavy oil + organic solvent interfaces. Difficulties such as the opacity of samples, the multiphase behaviours of these mixtures, and potential artefacts, all pose significant experimental challenges. Upgrades were made to the X-ray apparatus and data acquisition system to permit observations for atmospheric residue, where low mutual diffusion coefficient values were anticipated.

Mutual diffusion coefficient values for Athabasca bitumen + pentane mixtures were determined and compared favourably with values in the literature. Mutual diffusion coefficient values for atmospheric residue and pentane were also measured and found to be an order of magnitude smaller at room temperature.

Penetration times to reach 1 m into bitumen, predicted on the basis of these diffusion coefficients, obtained with a vertical geometry were compared with penetration times predicted from a correlation based on large scale measurements with random penetration geometries. Penetration times agreed within experimental error.

Asphaltene accumulation at the pentane bitumen interface, an question raised with respect to the appropriateness of the experimental method, proved not to be a measurement method artefact.

As the light ends fraction of bitumen and heavy oil decreases with depth in an oil reservoir, penetrant movement is expected to be primarily horizontal, or vertically upward, particularly where the composition gradients are pronounced because of the large difference in mutual diffusion coefficients with light ends composition.

Under forced mass transfer conditions, the anticipated shift from diffusion control limitations arising in the pentane rich phase to mass transfer limited by processes arising in the bitumen is observed, and the asymptotic behaviours are well predicted by theory. However, the transition between the two regimes is predicted to arise at lower local shear fields than is observed experimentally, particularly for atmospheric residue. This effect is attributed to the solids content of these two hydrocarbon resources.

7. Future Work

Fulem et al[21] showed that, at room temperature, heavy oils and bitumen contain solid maltenes and solid asphaltenes. As the temperature is increased, the maltenes melt and only asphaltenes remain solid. Consequently, the solids mass fraction decreases, which should result in smaller boundary layer thicknesses and significantly higher diffusion and mass transfer coefficients than at room temperature, as observed by Ninninger for bitumen + hexane. A temperature series, combined with phase behavior measurements would be instructive and of industrial relevance. Further, as phase behavior is important, a systematic study with diverse solvents would be equally instructive and industrially relevant.

8. References

1. Sparks, B.D. and F.W. Meadus, a study of some factors affecting solvent losses in the solvent-extraction - spherical agglomoration of oil sands. Fuel Processing Technology, 1981. 4(4): p. 251-264.
2. Tao, J.C., E.L. Cussler, and D.F. Evans, accelerating gallstone dissolution. Proceedings of the National Academy of Sciences of the United States of America, 1974. 71(10): p. 3917-3921.
3. Zou, X., X. Zhang, and J.M. Shaw. The phase behavior of athabasca vacuum bottoms + n-alkane mixtures. 2005. Calgary, AB, Canada: Society of Petroleum Engineers.
4. Zhang, X. and J.M. Shaw, Liquid-phase mutual diffusion coefficients for heavy oil plus light hydrocarbon mixtures. Petroleum Science and Technology, 2007. 25(5-6): p. 773-790.
5. Zhang, X.H., M. Fulem, and J.M. Shaw, Liquid-phase mutual diffusion coefficients for Athabasca bitumen plus pentane mixtures. Journal of Chemical and Engineering Data, 2007. 52(3): p. 691-694.
6. Luo, P. and Y. Gu, Characterization of a heavy oil-propane system in the presence or absence of asphaltene precipitation. Fluid Phase Equilibria, 2009. 277(1): p. 1-8.
7. Riazi, M.R., et al., - New method for experimental measurement of diffusion coefficients in reservoir fluids - 1996

8. Das, S.K. and R.M. Butler, Diffusion coefficients of propane and butane in peace river bitumen. Canadian Journal of Chemical Engineering, 1996. 74(6): p. 985-992.
9. Wen, Y., J. Bryan, and A. Kantzas. Estimation of diffusion coefficients in bitumen solvent mixtures as derived from low field NMR spectra. 2005: Canadian Inst Mining Metallurgy Petroleum.
10. Moghadam, S., M. Nobakht, and Y. Gu, Theoretical and physical modeling of a solvent vapour extraction (VAPEX) process for heavy oil recovery. Journal of Petroleum Science and Engineering, 2009. 65(1-2): p. 93-104.
11. Weng, L., et al., In situ investigation of drug diffusion in hydrogels by the refractive index method. Analytical Chemistry, 2004. 76(10): p. 2807-2812.
12. Russo, M.A.L., et al., A study of water diffusion into a high-amylose starch blend: The effect of moisture content and temperature. Biomacromolecules, 2007. 8(1): p. 296-301.
13. Wen, Y.W. and A. Kantzas. Monitoring bitumen-solvent interactions with low-field nuclear magnetic resonance and X-ray computer-assisted tomography. 2005: Amer Chemical Soc.
14. Mamidi, S.S., B. Meas, and T.R. Farhat, Rotational hydrodynamic diffusion system to study mass transport across boundaries. Analytical Chemistry, 2008. 80(21): p. 8109-8114.

15. Gregory, D.P. and A.C. Riddiford, DISSOLUTION OF COPPER IN SULFURIC ACID SOLUTIONS. Journal of the Electrochemical Society, 1960. 107(12): p. 950-956.
16. Gharehbagh, F.S. and S.M.A. Mousavian, Hydrodynamic characterization of mixer-settlers. Journal of the Taiwan Institute of Chemical Engineers, 2009. 40(3): p. 302-312.
17. Tezura, S., et al., Solid-liquid mass transfer characteristics of an unbaffled agitated vessel with an unsteadily forward-reverse rotating impeller. Journal of Chemical Technology and Biotechnology, 2008. 83(5): p. 763-767.
18. Torab-Mostaedi, M., et al., Mass transfer coefficients in a hanson mixer-settler extraction column. Brazilian Journal of Chemical Engineering, 2008. 25(3): p. 473-481.
19. Geankoplis, C.J., Transport Processes and separation process principles. 4 ed. Vol. 1. 2008: Prentice Hall.
20. Basmadjian, D., Mass Transfer Principles And Applications 2005 ed. 2005: CRC
21. Fulem, M., et al., Phase behaviour of Maya crude oil based on calorimetry and rheometry. Fluid Phase Equilibria, 2008. 272(1-2): p. 32-41.
22. Larter, S., et al., The origin, prediction and impact of oil viscosity heterogeneity on the production characteristics of tar sand and heavy oil reservoirs. Journal of Canadian Petroleum Technology, 2008. 47(1): p. 52-61.

23. Bazyleva, A.B., Hasan, MD. A., Fulem, M., Becerra, M. and Shaw, J.M., Bitumen and Heavy Oil Rheological Properties-Reconciliation with Viscosity Measurements, in 10th International Conference on Petroleum Phase Behavior and Fouling. 2009: Rio de Janiero, Brazil.

9. Appendix

9.1 MATLAB Code Utilized to Analyze the Images

MATLAB code which converted the X-ray transmitted images in to X-ray intensity profile:

```
clc
  imageaverage=zeros(1,600,40);
  imageaverage2=zeros(1,600);

for counter=1:100%average 100 picture
   image = double(imread(‘[File Location]',counter));    % Column Average
   for x = 71 : 480 % swap vertically
      temp = 0;
      for y = 200 : 260  % swap horizontally
         temp = temp + image(y,x);
      end; % of for
      imageaverage(1,x,counter) = temp/100 ;
   end; % of for
end;
for x = 1 : 600
   temp = 0 ;
```

```
    for counter = 1 : 100

        temp = temp + imageaverage(1,x,counter);

    end;

    imageaverage2(1,x) = temp/100;

end;% of for


plot(imageaverage2)

imageaverage2'
```

9.2 X-Ray Intensity Profile Data

Table 9-1 Bitumen + pentane, X-ray intensity profile, free diffusion

Elevation (m)	t=0 s	t=3960 s	t=9840 s	t=20220 s	t=82860 s	t=111180 s	t=168840 s	t=186480 s
0	37.29839	37.26555	37.25352	37.1777	37.29839	37.27835	37.08281	36.98207
9.20E-05	37.41212	37.45044	37.37777	37.31477	37.39451	37.41213	37.27435	37.1046
1.84E-04	37.36187	37.49194	37.42627	37.40076	37.41341	37.40675	37.28003	37.09706
2.76E-04	37.30253	37.39166	37.38933	37.37615	37.37322	37.3172	37.28189	37.06732
3.68E-04	37.19091	37.24633	37.21688	37.22856	37.23563	37.1618	37.1589	37.01425
4.60E-04	37.08283	37.22884	37.12297	37.20834	37.18425	37.16718	37.05471	37.00723
5.52E-04	37.2443	37.37681	37.33422	37.39658	37.3559	37.33343	37.26514	37.16601
6.44E-04	37.57319	37.56048	37.58025	37.59666	37.57457	37.54043	37.48713	37.42207
7.36E-04	37.77543	37.73826	37.68758	37.72504	37.71721	37.67341	37.56087	37.5782
8.28E-04	38.01743	37.97685	37.86302	37.91767	37.98053	37.88649	37.74085	37.76408
9.20E-04	38.04084	38.03949	37.99718	38.03349	38.10991	38.02844	37.86864	37.87642
0.00101	37.93447	38.01254	38.08995	38.08384	38.03309	38.01031	37.93915	37.98887
0.0011	37.94537	38.06492	38.19408	38.15615	38.06566	38.04796	38.03491	38.07626
0.0012	38.12541	38.17994	38.25363	38.20599	38.11862	38.11988	38.16593	38.18035
0.00129	38.27457	38.19693	38.25662	38.24399	38.09981	38.18234	38.29245	38.26977
0.00138	38.31211	38.16062	38.23082	38.20967	38.11327	38.27637	38.41104	38.27161
0.00147	38.3116	38.20964	38.24991	38.14103	38.1299	38.30695	38.47018	38.29992
0.00156	38.45642	38.47203	38.40905	38.32692	38.27344	38.37649	38.57937	38.48458
0.00166	38.63232	38.71224	38.54919	38.47665	38.40915	38.54672	38.74133	38.61148
0.00175	38.74686	38.89347	38.71576	38.50361	38.58546	38.7347	38.86011	38.76599
0.00184	38.93295	38.99548	38.93083	38.65702	38.81947	38.89099	39.02668	38.96389
0.00193	39.09472	39.05711	39.10833	38.86588	39.02735	38.94109	39.11598	39.05189
0.00202	39.05698	38.96578	39.1138	38.94075	39.01339	38.87854	38.97869	39.06706
0.00212	39.20705	39.06128	39.25271	39.11642	39.16772	39.05505	39.10041	39.25661
0.00221	39.45056	39.24861	39.37613	39.28749	39.35203	39.17768	39.34688	39.47752
0.0023	39.65048	39.37899	39.43981	39.48993	39.51844	39.37222	39.5206	39.59628
0.00239	39.71749	39.32926	39.42443	39.56704	39.58704	39.49853	39.56143	39.61339
0.00248	39.79923	39.53012	39.59296	39.73321	39.71424	39.59645	39.7704	39.79948
0.00258	39.84949	39.76515	39.69378	39.8476	39.79472	39.64038	39.88399	39.93555
0.00267	39.78258	39.822	39.71793	39.87885	39.78353	39.67634	39.89192	40.06022
0.00276	39.65593	39.81712	39.73527	39.81604	39.71434	39.71599	39.96566	40.14109
0.00285	39.67419	39.81081	39.75911	39.78959	39.73117	39.78522	40.1148	40.241
0.00294	39.86463	39.80451	39.83083	39.84832	39.83134	39.77476	40.2232	40.39969
0.00304	40.04708	39.92065	39.97954	40.04401	39.96825	39.91272	40.29938	40.64953
0.00313	40.10612	40.03293	40.06747	40.17627	39.9929	40.02559	40.25297	40.81616
0.00322	40.13115	40.19575	40.15209	40.18475	40.17949	40.14442	40.29116	40.97881
0.00331	40.1038	40.23745	40.1233	40.11101	40.25522	40.09233	40.31946	41.176
0.0034	40.11288	40.3125	40.15003	40.14246	40.30927	40.00178	40.43285	41.3139
0.0035	40.14175	40.30925	40.29926	40.20763	40.38846	40.10976	40.61087	41.53227
0.00359	40.17505	40.22992	40.39327	40.29219	40.40499	40.26546	40.83688	41.81807

0.00368	40.26032	40.25891	40.40772	40.331	40.44419	40.42653	41.05113	42.02452
0.00377	40.35307	40.38715	40.50318	40.38176	40.46944	40.62904	41.2694	42.23301
0.00386	40.45439	40.45458	40.60875	40.40168	40.41341	40.72886	41.41551	42.32335
0.00396	40.53654	40.42722	40.58037	40.47072	40.5216	40.73165	41.58158	42.4034
0.00405	40.52089	40.40037	40.57635	40.58879	40.68593	40.74629	41.91579	42.66394
0.00414	40.5325	40.55974	40.70886	40.71288	40.81847	40.91553	42.33657	42.97377
0.00423	40.49324	40.57977	40.75447	40.66856	40.7766	40.99114	42.61751	43.15853
0.00432	40.4991	40.50421	40.64838	40.48349	40.61683	40.89222	42.66148	43.34278
0.00442	40.50868	40.46668	40.47243	40.36695	40.55259	40.86075	42.62476	43.43801
0.00451	40.57388	40.45102	40.39451	40.41864	40.63524	40.88435	42.65776	43.54526
0.0046	40.66198	40.44421	40.52681	40.66008	40.77472	40.99323	42.83225	43.72146
0.00469	40.72354	40.44207	40.70937	40.881	40.83075	41.1041	43.05092	43.92954
0.00478	40.7527	40.5934	40.82898	40.91348	40.88866	41.09175	43.325	44.22613
0.00488	40.85957	40.82619	40.89617	40.86854	40.9822	41.16447	43.62768	44.63323
0.00497	40.90055	40.87277	40.91681	40.96332	41.0124	41.30303	43.90921	44.95284
0.00506	41.0166	40.92322	41.00308	41.14297	41.10693	41.5163	44.12503	45.21918
0.00515	41.11651	41.01139	41.04353	41.24562	41.27779	41.69441	44.21728	45.45945
0.00524	41.19613	41.08187	41.06861	41.23418	41.45845	41.77589	44.43995	45.6711
0.00534	41.23963	41.13455	41.07068	41.28351	41.55021	41.74252	44.71257	45.78761
0.00543	41.22056	41.14594	41.1908	41.30404	41.54417	41.67528	44.95277	45.89598
0.00552	41.2581	41.23422	41.33827	41.31895	41.58664	41.83297	45.09672	46.16182
0.00561	41.20279	41.1913	41.28482	41.2255	41.51081	42.03579	45.14833	46.42062
0.0057	41.09976	41.01953	41.19957	41.17157	41.35876	42.04465	45.25555	46.50872
0.0058	41.09946	41.02868	41.21113	41.26819	41.33995	42.10621	45.48273	46.69521
0.00589	40.99228	41.00569	41.13332	41.13817	41.21483	42.09286	45.53982	46.67087
0.00598	40.99157	41.01464	41.09864	41.12071	41.10891	42.21848	45.701	46.71915
0.00607	40.96392	41.03936	41.09173	41.22254	41.21839	42.42209	45.90351	46.85104
0.00616	40.81618	40.94081	41.00938	41.14032	41.31075	42.5463	45.87961	46.82283
0.00626	40.84898	40.83952	40.97811	41.0343	41.3058	42.73776	46.0311	46.94352
0.00635	41.1597	40.97874	41.20979	41.18781	41.53764	43.17815	46.49467	47.3331
0.00644	41.2358	41.06295	41.27759	41.17096	41.68236	43.46434	46.75299	47.59323
0.00653	41.18473	41.01322	41.23879	41.09773	41.78571	43.5792	46.78814	47.62511
0.00662	41.11631	40.96054	41.17109	41.03359	41.84758	43.61048	46.87265	47.66117
0.00672	41.1926	41.0957	41.17099	41.24317	41.93003	43.80263	47.07408	47.75406
0.00681	41.18554	41.10119	41.00793	41.39361	41.97369	43.97705	47.20804	47.78665
0.0069	41.17333	41.12977	41.00876	41.39555	41.92776	44.1203	47.32084	47.97405
0.00699	41.15375	41.0839	41.09204	41.20354	41.88796	44.30229	47.42797	48.15902
0.00708	41.06363	41.01424	41.0037	41.03818	41.92845	44.4544	47.52815	48.29774
0.00718	41.14961	41.15641	41.02568	41.16156	42.28016	44.71748	47.82622	48.62539
0.00727	41.29534	41.27469	41.11485	41.35919	42.65355	45.04531	48.1386	48.88318
0.00736	41.3349	41.30805	41.20556	41.52271	42.90796	45.24902	48.36695	49.00295
0.00745	41.26627	41.26076	41.27749	41.54089	43.14771	45.38559	48.49132	49.12894
0.00754	41.28827	41.25273	41.3681	41.50249	43.37846	45.61878	48.65475	49.32837
0.00764	41.57104	41.36826	41.54199	41.62617	43.69859	45.99801	48.99317	49.6219
0.00773	41.80013	41.50688	41.66511	41.65477	43.96488	46.41539	49.29262	49.84221
0.00782	41.89257	41.71333	41.86005	41.63782	44.42379	46.9288	49.6375	50.19818
0.00791	41.82899	41.79886	41.87068	41.6564	44.81609	47.24318	49.78811	50.48896
0.008	41.65672	41.71811	41.70917	41.76906	44.92746	47.36321	49.79134	50.58766

0.0081	41.55116	41.67427	41.66944	41.81257	45.03991	47.44539	49.89455	50.66415
0.00819	41.51514	41.7477	41.69308	41.7856	45.26699	47.62709	50.11292	50.7988
0.00828	41.5001	41.70051	41.59359	41.73709	45.46794	47.75579	50.32855	50.91511
0.00837	41.58739	41.6639	41.61516	41.79398	45.59198	47.88628	50.4958	51.00148
0.00846	41.59587	41.5503	41.64375	41.75292	45.73007	48.1143	50.54025	51.13857
0.00856	41.65743	41.55244	41.65892	41.74332	45.94854	48.25326	50.65796	51.3108
0.00865	41.61736	41.55925	41.66934	41.79061	46.14345	48.42848	50.70016	51.40787
0.00874	41.4345	41.50098	41.6389	41.67397	46.23056	48.60848	50.67549	51.29838
0.00883	41.3789	41.38992	41.63157	41.54416	46.3741	48.74097	50.79525	51.2445
0.00892	41.47416	41.27632	41.57956	41.55989	46.58752	48.86638	50.86066	51.29899
0.00902	41.50454	41.25618	41.56954	41.5941	46.89577	48.92206	51.01312	51.46093
0.00911	41.61807	41.31191	41.68523	41.6707	47.30688	49.04578	51.3348	51.73399
0.0092	41.65511	41.39978	41.79607	41.85536	47.72551	49.36375	51.60135	52.06705
0.00929	41.74301	41.50596	41.86418	42.02102	48.12286	49.72216	51.82451	52.34072
0.00938	41.94767	41.61824	41.84664	42.17923	48.42755	50.00705	52.04699	52.58364
0.00948	42.15717	41.72868	42.00742	42.43191	48.63958	50.37403	52.33831	52.88705
0.00957	42.18281	41.71587	42.03756	42.44744	48.71462	50.64617	52.45533	53.03402
0.00966	42.18311	41.77781	42.04457	42.3788	48.82163	50.89341	52.53083	53.09849
0.00975	42.05363	41.78116	42.00753	42.15135	48.9809	50.93017	52.60094	53.01538
0.00984	41.97855	41.80252	42.14705	42.2207	49.38716	51.1031	52.82147	53.10135
0.00994	41.95685	41.90534	42.36945	42.4313	49.79985	51.33002	53.24087	53.41464
0.01003	42.06867	42.1126	42.59453	42.50729	50.19046	51.55047	53.55726	53.84751
0.01012	42.26082	42.36919	42.71331	42.71554	50.57979	51.94752	53.85093	54.25888
0.01021	42.28039	42.38811	42.75923	42.83259	50.83093	52.27107	54.00878	54.41349
0.0103	42.26233	42.34306	42.66006	42.90439	51.00723	52.48265	54.05245	54.42796
0.0104	42.32611	42.43561	42.53488	42.95351	51.1083	52.68437	54.15175	54.57615
0.01049	42.25204	42.49317	42.42548	42.88447	51.15512	52.65458	54.22891	54.69277
0.01058	42.18553	42.50141	42.49803	42.87732	51.3334	52.75649	54.34123	54.77843
0.01067	42.25587	42.48117	42.55335	43.00734	51.52713	52.97225	54.35063	54.87631
0.01076	42.33166	42.43764	42.48235	43.05973	51.61572	53.05901	54.30588	54.93253
0.01086	42.33691	42.38038	42.48751	43.10723	51.6963	53.26192	54.45227	55.06779
0.01095	42.54379	42.48605	42.73467	43.40413	52.11255	53.71795	54.8187	55.37853
0.01104	42.70607	42.55378	42.85345	43.78969	52.49525	53.97406	55.15712	55.56788
0.01113	42.5997	42.50883	42.90103	44.1154	52.6961	54.13374	55.34562	55.83585
0.01122	42.54813	42.47883	43.08648	44.44458	53.02405	54.24023	55.50357	56.04861
0.01132	42.60101	42.55022	43.16791	44.71758	53.27876	54.36813	55.72096	56.12001
0.01141	42.62039	42.57066	42.97203	44.86721	53.22718	54.56865	55.76375	56.09292
0.0115	42.71	42.56883	42.96986	45.15829	53.44456	54.84996	55.99475	56.22217
0.01159	42.84442	42.74061	43.21723	45.53251	53.92308	55.07768	56.29969	56.35356
0.01168	42.97259	43.11232	43.45428	45.92144	54.30251	55.25619	56.58033	56.61134
0.01178	42.95675	43.20517	43.4999	46.16483	54.42219	55.42403	56.64349	56.76666
0.01187	42.76904	43.06574	43.48813	46.47307	54.41694	55.53221	56.61676	56.81301
0.01196	42.65409	42.96333	43.5612	46.8431	54.42338	55.55602	56.57593	56.87952
0.01205	42.63583	42.90353	43.61682	47.13439	54.50584	55.49267	56.42473	56.83083
0.01214	42.75723	42.97614	43.82033	47.5751	54.84468	55.66321	56.46283	56.99176
0.01224	43.04041	43.16317	44.19918	48.11519	55.40863	56.16606	56.90407	57.484
0.01233	43.25122	43.32203	44.67091	48.78938	55.8521	56.46589	57.32416	57.83508
0.01242	43.39281	43.53702	45.2414	49.3025	56.127	56.60127	57.56759	57.90465

0.01251	43.23619	43.65784	45.5735	49.49288	56.06958	56.68713	57.66552	57.72661
0.0126	43.26697	43.78568	45.91395	49.94697	55.99831	57.00719	57.84197	57.81186
0.0127	43.55539	44.0082	46.42541	50.66886	56.33567	57.42945	58.13231	58.13554
0.01279	43.79527	44.15475	47.01097	51.21508	56.72074	57.63705	58.33795	58.42939
0.01288	43.82777	44.22615	47.44709	51.62862	57.00563	57.74333	58.41404	58.51168
0.01297	43.82706	44.52728	48.08435	52.14848	57.38586	57.93828	58.63946	58.54254
0.01306	43.86652	44.89544	48.57661	52.63097	57.6461	58.06001	58.72631	58.54163
0.01316	44.11336	45.25403	49.25876	53.27217	57.93594	58.37887	58.86047	58.76835
0.01325	44.38513	45.63246	50.09427	53.78631	58.13541	58.71656	59.01724	59.21435
0.01334	44.36313	45.9758	50.52245	54.03583	58.06483	58.71516	59.10645	59.29991
0.01343	44.31005	46.35647	50.81853	54.3883	58.03325	58.63946	59.27194	59.36794
0.01352	44.3813	46.88257	51.14691	54.61309	58.11254	58.60141	59.33393	59.36957
0.01362	44.43791	47.33229	51.511	54.71809	58.11739	58.57162	59.13348	59.18288
0.01371	44.51956	47.78445	52.03959	54.98548	58.15422	58.61894	59.00167	59.11332
0.0138	44.63874	48.34034	52.75249	55.19158	58.32428	58.86727	59.07355	59.27984
0.01389	44.7884	49.04482	53.43227	55.42762	58.52296	59.22977	59.28438	59.59293
0.01398	45.16604	49.84989	53.92681	55.94197	58.84349	59.48448	59.56179	59.82892
0.01408	45.57818	50.53281	54.35467	56.43129	59.18619	59.61557	59.78153	59.93454
0.01417	45.90041	51.18501	54.67315	56.80419	59.35526	59.6333	59.94682	60.05524
0.01426	46.29268	51.96323	55.14611	57.33437	59.55057	59.86082	60.12974	60.30121
0.01435	46.57555	52.6256	55.48595	57.59982	59.51028	59.8661	60.00176	60.31007
0.01444	46.98467	53.33273	55.91991	57.90673	59.47643	59.82914	59.93321	60.27381
0.01454	47.76104	54.27508	56.62074	58.46418	59.89169	60.14213	60.21533	60.43127
0.01463	48.76123	55.07913	57.14551	58.89795	60.34358	60.4057	60.4619	60.57906
0.01472	50.12372	55.8729	57.78297	59.41965	60.75479	60.64747	60.69917	60.72165
0.01481	51.66887	56.68112	58.34975	59.77886	60.84388	60.88176	60.77241	60.95917
0.0149	53.12623	57.37573	58.83045	60.10855	60.72925	60.98715	60.80061	61.19933
0.015	54.98301	58.42722	59.56255	60.89427	61.116	61.38769	61.23089	61.63536
0.01509	57.06171	59.41646	60.3027	61.64057	61.63808	61.70456	61.45268	61.76491
0.01518	59.05555	60.17179	60.97753	62.14674	62.05581	61.87331	61.52622	61.65175
0.01527	61.16584	60.98275	61.60116	62.60359	62.49276	62.07333	61.72285	61.82877
0.01536	63.40581	62.06057	62.33904	63.23152	62.93376	62.44121	62.2724	62.20888
0.01546	65.64487	62.97323	62.88456	63.8623	63.07799	62.87154	62.56528	62.39792
0.01555	67.84619	63.87257	63.40531	64.48624	63.2627	63.22417	62.67339	62.67006
0.01564	69.76322	64.85714	64.0502	65.13244	63.40099	63.524	62.86816	62.91267
0.01573	71.59225	65.9373	64.90841	65.71042	63.73627	63.83241	63.23733	63.2331
0.01582	73.2354	66.75853	65.58396	66.11947	63.93247	63.92535	63.34681	63.31223
0.01592	74.97138	67.86615	66.35548	66.67754	64.29002	64.24012	63.48909	63.48874
0.01601	76.4141	68.72257	66.914	67.24449	64.59996	64.43467	63.54481	63.57908
0.0161	77.41813	69.47933	67.51803	67.9391	64.87317	64.58817	63.68552	63.62471
0.01619	78.44396	70.37501	68.41009	68.76364	65.31308	64.7884	63.95128	63.87822
0.01628	79.57021	71.36232	69.44952	69.55783	65.74181	65.14262	64.25749	64.28033
0.01638	80.60461	72.26938	70.35654	70.30893	66.08164	65.46467	64.59718	64.55472
0.01647	81.4608	73.29117	71.14086	70.9105	66.48918	65.79539	64.89927	64.96355
0.01656	81.97316	74.06552	71.70856	71.41147	66.76923	66.10708	64.91347	65.18171
0.01665	82.28893	74.55348	72.15036	71.91112	66.94117	66.36598	64.88782	65.20157
0.01674	82.60601	74.96628	72.74283	72.38747	67.19073	66.49338	65.15045	65.25881
0.01684	82.97719	75.57099	73.46379	72.95095	67.49512	66.63055	65.5911	65.43532

0.01693	83.18155	76.27751	74.06978	73.43803	67.6934	66.80677	65.84149	65.59574
0.01702	83.38257	77.02328	74.5124	73.93216	67.89227	67.10441	65.92893	65.76797
0.01711	83.71005	77.84421	75.21488	74.70654	68.33634	67.64272	66.22427	66.20796
0.0172	83.95397	78.49326	75.95204	75.2691	68.86475	68.09019	66.63623	66.62067
0.0173	84.07477	78.92071	76.46773	75.68897	69.32307	68.4726	66.92863	66.88334
0.01739	84.18911	79.36697	76.96949	76.22845	69.88662	68.88789	67.21593	67.0629
0.01748	84.3752	79.72933	77.46475	76.74607	70.29981	69.18394	67.52684	67.34381
0.01757	84.77463	80.31533	78.05309	77.27951	70.65578	69.62503	67.8823	67.68155
0.01766	84.82045	80.65765	78.46135	77.65006	70.86633	69.94897	68.10733	67.92681
0.01776	84.93661	80.93926	78.76733	78.01294	71.15657	70.18386	68.44663	68.22472
0.01785	85.14712	81.19026	79.0146	78.37123	71.41068	70.58829	68.74784	68.52722
0.01794	85.42646	81.53289	79.45537	78.89161	71.94176	71.1269	69.06521	68.89052
0.01803	85.55533	81.76436	79.80965	79.29289	72.35059	71.46977	69.44662	69.14433
0.01812	85.69561	82.14736	80.14299	79.8529	72.77654	71.85846	69.9517	69.48319
0.01822	85.94054	82.57257	80.52194	80.59674	73.17715	72.2364	70.41762	70.01547
0.01831	85.98595	82.7418	80.63401	80.85055	73.38979	72.39339	70.62316	70.36166
0.0184	86.16256	82.93453	80.79852	80.95309	73.76813	72.63764	70.80843	70.63004
0.01849	86.4971	83.13782	81.0979	81.3842	74.15359	73.17386	71.1636	71.03143
0.01858	86.6513	83.21196	81.46601	81.84912	74.49927	73.525	71.52523	71.33617
0.01868	86.64232	83.34651	81.87768	82.11375	74.86642	73.78668	71.8565	71.52704
0.01877	86.62597	83.63423	82.09636	82.32884	75.08677	74.07068	72.12667	71.7941
0.01886	86.75686	83.81393	82.28996	82.63504	75.26179	74.32489	72.37089	72.0858
0.01895	86.85495	83.78566	82.42794	82.90233	75.51649	74.52193	72.56399	72.28858
0.01904	86.78835	83.89743	82.51721	83.06789	75.80198	74.7874	72.76405	72.41437
0.01914	86.673	83.93089	82.44311	83.14153	75.91552	74.89548	72.8748	72.35957
0.01923	86.69843	84.01245	82.57386	83.30739	76.01748	75.02587	73.25866	72.55299
0.01932	86.85172	84.16734	82.86024	83.79161	76.35612	75.39743	73.75816	73.03189
0.01941	86.88048	84.29935	83.07634	84.04685	76.71575	75.67605	73.95469	73.47739
0.0195	86.85596	84.39922	83.20245	84.18841	76.89938	75.73492	73.9638	73.60124
0.0196	87.01491	84.56855	83.38264	84.54394	77.17497	76.05757	74.19695	73.80138
0.01969	87.15851	84.74337	83.55179	84.87679	77.36988	76.41299	74.40543	74.10113
0.01978	87.1571	84.81629	83.6168	84.87812	77.39978	76.62148	74.63545	74.36054
0.01987	87.2234	84.87874	83.72196	84.86852	77.50589	76.90279	74.89975	74.46127
0.01996	87.25075	84.99569	83.99214	85.01274	77.70803	77.00011	74.96634	74.45486
0.02006	87.30262	85.07339	84.26129	85.25183	78.01846	76.98816	74.96957	74.69777
0.02015	87.37407	85.17255	84.36294	85.44007	78.25139	77.02043	75.2228	75.00424
0.02024	87.3004	85.14723	84.34302	85.52269	78.35632	77.12234	75.38094	75.20092
0.02033	87.31393	85.30049	84.36263	85.92837	78.4757	77.4664	75.59755	75.46644
0.02042	87.5643	85.66478	84.48967	86.48092	78.68883	77.906	76.01264	75.81223
0.02052	87.861	85.995	84.75406	86.80918	78.9363	78.2144	76.37368	76.24
0.02061	87.75241	85.90317	84.69101	86.84084	79.0047	78.17794	76.27145	76.28247
0.0207	87.65079	85.85954	84.66831	86.9919	79.14299	78.33523	76.27429	76.22422
0.02079	87.77139	85.97253	84.88812	87.14296	79.33919	78.56862	76.50372	76.38514
0.02088	87.89703	86.17318	85.14849	87.22701	79.60092	78.83121	76.80689	76.70231
0.02098	87.78451	86.07524	85.06119	87.23488	79.50886	78.80451	76.88807	76.88116
0.02107	87.83335	85.97497	85.01258	87.41116	79.50064	78.82583	76.95867	76.88421
0.02116	87.69398	85.86391	84.90247	87.24928	79.35503	78.66336	76.81287	76.69711
0.02125	87.68207	85.96876	84.92373	87.33834	79.64022	78.7306	76.95887	76.84816

0.02134	87.79641	86.1562	85.07213	87.40708	79.96639	79.00145	77.21445	77.11959
0.02144	87.8504	86.19413	85.24509	87.51575	80.15319	79.22428	77.40001	77.34845
0.02153	88.04709	86.26349	85.55758	87.92725	80.44234	79.54972	77.75743	77.70014
0.02162	88.04396	86.24468	85.67564	88.05614	80.54044	79.71747	77.82656	77.8134
0.02171	87.92993	86.13535	85.63849	87.97719	80.45758	79.74924	77.73236	77.79639
0.0218	88.03952	86.30763	85.68441	88.10445	80.63101	79.82774	77.88581	78.10215
0.0219	88.16658	86.53208	85.75087	88.26695	80.85809	79.93134	78.13855	78.39782
0.02199	88.04306	86.39133	85.59339	88.30106	80.7793	80.02238	78.18545	78.23191
0.02208	88.02913	86.36814	85.71527	88.37858	80.88393	80.27082	78.23177	78.17884
0.02217	88.15891	86.63094	86.0225	88.54486	81.09923	80.53768	78.42889	78.40078
0.02226	87.88906	86.49334	85.84448	88.31138	80.85018	80.33447	78.24705	78.33447
0.02236	87.46783	86.11226	85.43178	87.99558	80.54331	79.96929	77.9614	78.13881
0.02245	87.4208	85.94486	85.27409	88.10803	80.51381	80.01601	78.00939	78.21174
0.02254	87.7836	86.25902	85.63013	88.64689	81.07112	80.54944	78.56441	78.68362
0.02263	88.14347	86.78379	86.07358	89.14939	81.59775	80.8684	79.03532	79.222
0.02272	88.13479	86.94895	86.08359	89.10026	81.68991	80.95287	79.06421	79.28963
0.02282	87.73728	86.62911	85.86274	88.7288	81.44481	80.68461	78.90058	78.99701
0.02291	87.6303	86.47544	85.75428	88.65833	81.26554	80.63849	78.82783	78.8643
0.023	87.76069	86.43557	85.8065	88.82103	81.32533	80.81292	78.83311	79.01738
0.02309	87.72173	86.41086	85.89401	88.75219	81.52935	80.90755	78.80795	79.1396
0.02318	87.53453	86.26319	85.75665	88.53229	81.58369	80.73402	78.71531	78.91217
0.02328	87.38911	86.1207	85.56934	88.67314	81.46312	80.56568	78.66253	78.65286
0.02337	87.2456	86.01402	85.34344	88.53148	81.21179	80.44704	78.66762	78.60621
0.02346	87.24127	86.00924	85.29122	88.24918	81.17714	80.51457	78.73842	78.89801
0.02355	87.36378	86.04707	85.45613	88.22865	81.38037	80.63321	78.79718	79.11353
0.02364	87.5201	86.16861	85.68854	88.59541	81.6024	80.88255	78.96835	79.24166
0.02374	87.62324	86.30112	85.91259	89.00395	81.83156	81.20081	79.34819	79.42041
0.02383	87.70337	86.40994	86.05851	89.23692	82.06637	81.47017	79.67378	79.55781
0.02392	87.61163	86.47127	86.05862	89.16859	82.11873	81.43271	79.73939	79.57522
0.02401	87.7403	86.59453	86.16677	89.23702	82.28524	81.4874	79.93406	79.77047
0.0241	87.85071	86.59707	86.27399	89.37868	82.31731	81.54946	79.92593	80.07541
0.0242	87.87422	86.58476	86.31992	89.4513	82.40135	81.75377	79.88804	80.28472
0.02429	87.8829	86.59717	86.29597	89.39349	82.51192	81.91514	79.805	80.27362
0.02438	87.80751	86.50656	86.21104	89.31005	82.41749	81.95469	79.84573	80.18521
0.02447	87.72769	86.46476	86.04706	89.2504	82.33245	81.78465	79.99056	80.10689
0.02456	87.48407	86.34373	85.93405	88.94829	82.21436	81.42863	79.81587	79.89829
0.02466	87.17244	86.20379	85.70082	88.66956	82.0338	81.2026	79.51035	79.77159
0.02475	87.07838	86.16545	85.65242	88.75413	81.98143	81.36089	79.54962	79.7887
0.02484	87.18314	86.08531	85.73612	88.83288	82.11151	81.57855	79.66272	79.78351
0.02493	87.27447	85.97273	85.75903	88.91285	82.24742	81.59687	79.72911	79.84166
0.02502	87.33805	85.89432	85.85459	89.09036	82.24208	81.59618	79.88461	80.00697
0.02512	87.4865	86.0486	86.07182	89.2789	82.44372	81.79839	80.15664	80.2563
0.02521	87.51627	86.18111	86.20144	89.44017	82.58765	81.86563	80.25985	80.31853
0.0253	87.72678	86.46059	86.3807	89.7574	82.86403	82.08657	80.47949	80.45399
0.02539	87.7728	86.54714	86.29907	89.71951	82.96015	82.25572	80.49614	80.51205
0.02548	87.67531	86.50778	86.21837	89.46182	82.84493	82.22553	80.49692	80.58212
0.02558	87.45894	86.44147	86.1743	89.28697	82.64942	82.11287	80.47215	80.62541
0.02567	87.25015	86.3417	86.05201	89.16992	82.58201	82.06177	80.29089	80.50482

0.02576	87.00088	86.08023	85.79174	88.81357	82.31464	81.89542	79.95972	80.15211
0.02585	86.98604	85.99592	85.71362	88.93144	82.32661	81.95538	80.07644	80.19203
0.02594	87.14913	86.05399	85.87296	89.23079	82.65932	82.13618	80.36796	80.44961
0.02604	86.92125	85.84805	85.89597	88.96933	82.6222	81.91185	80.22979	80.38392
0.02613	86.67905	85.58647	85.7196	88.7287	82.2686	81.60972	80.00006	80.25793
0.02622	86.57985	85.38368	85.42579	88.47214	81.98193	81.38789	79.84926	80.0855
0.02631	86.51375	85.34269	85.30608	88.42832	81.93451	81.38729	79.97157	80.14966
0.0264	86.48024	85.2831	85.20288	88.34651	81.94204	81.44078	80.00545	80.02938
0.0265	86.4089	85.22787	85.04994	88.38593	81.99727	81.51718	79.96334	79.88964
0.02659	86.43897	85.32307	85.23033	88.62963	82.1516	81.5914	80.01377	79.9094
0.02668	86.52556	85.3312	85.39329	88.80305	82.2885	81.66601	80.01475	80.12664
0.02677	86.44048	85.26805	85.32404	88.62636	82.14873	81.52336	79.83183	80.20385
0.02686	86.24763	85.11194	85.11207	88.4848	81.87136	81.31288	79.64382	80.05087
0.02696	86.07314	84.9901	84.89885	88.27941	81.70792	81.14622	79.62619	79.83423
0.02705	85.99422	84.99284	84.85685	88.20812	81.67318	81.22024	79.73205	79.63603
0.02714	85.96839	85.04685	84.99359	88.29115	81.89323	81.47206	79.88941	79.79624
0.02723	85.94942	85.06881	85.13033	88.25296	82.07627	81.66033	79.90527	79.98242
0.02732	85.8818	85.03647	85.09143	88.20965	82.11665	81.5906	79.89714	79.97631
0.02742	85.64394	84.81995	84.90102	88.11558	81.87403	81.37115	79.78992	79.88454
0.02751	85.5732	84.71581	84.77398	87.99639	81.64823	81.21735	79.64568	79.84655
0.0276	85.82953	84.83602	84.80443	88.15889	81.75584	81.35611	79.66703	79.99841
0.02769	86.12461	84.9844	84.92961	88.43087	82.00361	81.56838	79.77288	80.11768
0.02778	86.18657	85.05142	84.97182	88.53587	82.21822	81.73075	80.04648	80.22636
0.02788	86.06184	85.03291	84.99514	88.52075	82.24435	81.80387	80.34534	80.31456
0.02797	85.816	84.7989	84.7553	88.20689	81.95867	81.69908	80.10494	80.10342
0.02806	85.72245	84.64716	84.57243	88.03122	81.86928	81.55205	79.86512	80.02815
0.02815	85.84154	84.79788	84.79927	88.15766	82.09428	81.6429	80.01465	80.21638
0.02824	86.13046	85.14763	85.01877	88.44282	82.35581	81.9243	80.28962	80.40011
0.02834	86.27286	85.3129	85.02693	88.609	82.49104	82.05061	80.44551	80.47722
0.02843	86.2449	85.31869	85.0325	88.74044	82.54172	82.18519	80.54236	80.51887
0.02852	86.00906	85.12943	84.95912	88.72666	82.39749	82.13389	80.4085	80.47202
0.02861	85.70954	84.83185	84.81279	88.46121	82.25772	81.87988	80.09789	80.39197
0.0287	85.50205	84.51882	84.65148	88.19249	82.17417	81.64339	79.92466	80.40541
0.0288	85.37711	84.4578	84.57377	88.04869	82.0923	81.56201	79.92192	80.44839
0.02889	85.36722	84.4816	84.50061	87.86709	82.06746	81.55932	80.04726	80.35438
0.02898	85.50064	84.58421	84.55076	88.05144	82.22693	81.81373	80.21069	80.39543
0.02907	85.50356	84.66181	84.60195	88.13111	82.37146	81.94851	80.31576	80.4763
0.02916	85.42414	84.66506	84.57863	87.95033	82.31939	81.93317	80.33486	80.51775
0.02926	85.43383	84.57384	84.49906	87.86035	82.16744	81.84143	80.26044	80.51765
0.02935	85.40466	84.48627	84.45334	87.77088	82.10596	81.64718	80.04178	80.35937
0.02944	85.37964	84.40857	84.32568	87.61952	82.08943	81.52784	79.87051	80.29775
0.02953	85.30919	84.32142	84.22919	87.35203	82.13625	81.56639	79.84201	80.34114
0.02962	85.15075	84.14497	84.16263	87.18626	82.17447	81.63283	79.77641	80.15323
0.02972	85.18426	84.08161	84.31959	87.33926	82.22931	81.60116	79.80843	80.11941
0.02981	85.26116	84.10256	84.381	87.36224	82.09062	81.49198	79.93808	80.16199
0.0299	85.25359	84.2307	84.46067	87.55711	82.09458	81.47086	80.19228	80.33625
0.02999	85.27125	84.4517	84.54705	87.78916	82.31889	81.65126	80.33525	80.45583
0.03008	85.35209	84.55218	84.54209	87.95911	82.29662	81.91544	80.30646	80.52264

0.03018	85.37449	84.46736	84.48151	87.96279	82.07637	81.92141	80.2811	80.43637
0.03027	85.38468	84.31684	84.38554	87.80826	82.04647	81.77867	80.26768	80.34583
0.03036	85.08899	83.93617	84.13507	87.4415	81.89373	81.45692	80.0407	80.10373
0.03045	84.85264	83.77803	84.05396	87.3028	81.80503	81.34495	79.9133	79.99923
0.03054	84.78735	83.79868	84.02578	87.25193	81.87551	81.36956	79.9415	80.07541
0.03064	84.79573	83.85278	83.93548	87.33477	82.03825	81.38659	79.93798	80.07928
0.03073	84.68421	83.7464	83.75808	87.26286	81.98896	81.31148	79.78659	80.02001
0.03082	84.56351	83.54208	83.62041	86.98792	81.82374	81.15021	79.758	79.89402
0.03091	84.42384	83.42686	83.46778	86.73993	81.69832	81.03197	79.76456	79.75132
0.031	84.25218	83.30533	83.32495	86.59695	81.59478	80.95357	79.68367	79.65915
0.0311	84.26217	83.23739	83.45148	86.69755	81.58161	81.13427	79.63951	79.73299
0.03119	84.43888	83.36045	83.60535	86.76414	81.57557	81.20739	79.74331	79.85806
0.03128	84.67775	83.57148	83.60886	86.88415	81.62893	81.26606	79.97744	80.06299
0.03137	84.68098	83.57951	83.64539	87.11242	81.76702	81.47126	80.06293	80.19875
0.03146	84.3637	83.28732	83.50246	86.94134	81.64299	81.32702	79.76054	80.01746
0.03156	84.07204	83.06002	83.27635	86.67896	81.50252	81.09841	79.53228	79.83107
0.03165	83.9129	83.06226	83.11184	86.66834	81.43669	80.91851	79.45904	79.71812
0.03174	84.06468	83.16589	83.11793	86.72451	81.48777	80.87428	79.47666	79.72413
0.03183	83.98435	83.05301	83.08336	86.47673	81.42412	80.82138	79.29257	79.63776
0.03192	83.86698	82.94937	83.14043	86.20863	81.29771	80.7901	79.20287	79.55882
0.03202	83.80421	82.95893	83.21504	86.25633	81.24614	80.86621	79.31303	79.55516
0.03211	83.66716	82.80415	83.00142	86.16951	81.1416	80.6871	79.23626	79.35899
0.0322	83.37793	82.57929	82.62361	85.87271	80.96342	80.38946	79.02583	79.05059
0.03229	83.24906	82.56067	82.57717	85.79723	80.96293	80.41486	79.03807	79.11272
0.03238	83.44615	82.70865	82.74414	86.15899	81.08409	80.77198	79.20728	79.43681
0.03248	83.61963	82.82825	82.89523	86.29667	81.24534	80.88105	79.19269	79.56443
0.03257	83.64567	82.77241	82.95498	86.0109	81.22446	80.81521	79.11954	79.3922
0.03266	83.46492	82.51745	82.8329	85.67753	80.97599	80.6356	79.10025	79.17841
0.03275	83.2202	82.32829	82.61824	85.53536	80.71515	80.34832	78.89696	79.00923
0.03284	83.18074	82.39592	82.47913	85.53015	80.67734	80.3014	78.8383	79.05222
0.03294	83.14572	82.34039	82.29202	85.43782	80.73119	80.32591	78.74361	79.08868
0.03303	83.15914	82.28974	82.26395	85.40657	80.75802	80.37412	78.72981	79.11852
0.03312	83.15692	82.19862	82.2782	85.4131	80.72485	80.35967	78.77201	79.25724
0.03321	83.06307	82.10404	82.18738	85.49175	80.65437	80.34882	78.78513	79.3487
0.0333	82.99162	82.05085	82.10812	85.528	80.60547	80.37641	78.76094	79.27069
0.0334	82.90877	81.99807	82.07365	85.37593	80.64952	80.39394	78.71688	79.25327
0.03349	82.76758	82.10261	82.02205	85.21997	80.63952	80.28148	78.61729	79.19134
0.03358	82.6374	82.09814	81.91906	85.07984	80.45392	80.10377	78.40617	79.03164
0.03367	82.43435	81.88416	81.81627	84.93001	80.39383	79.9917	78.20445	78.79372
0.03376	82.22424	81.71595	81.6914	84.69765	80.39888	79.92197	78.17527	78.70073
0.03386	82.10657	81.58079	81.61152	84.4656	80.27079	79.76389	78.21649	78.6278
0.03395	82.07549	81.40729	81.6237	84.40595	80.27385	79.67115	78.22834	78.53461
0.03404	82.03512	81.49607	81.6333	84.47918	80.15913	79.67752	78.2305	78.56211
0.03413	82.03825	81.65208	81.76292	84.66425	80.11814	79.7609	78.32764	78.6275
0.03422	82.02452	81.62055	81.68077	84.62616	80.05538	79.80035	78.26967	78.58513
0.03432	82.06711	81.54092	81.601	84.4514	80.00718	79.91131	78.2397	78.60804
0.03441	82.08538	81.45519	81.56508	84.50594	79.96164	79.78461	78.2494	78.56751
0.0345	82.34605	81.51916	81.74589	84.89457	80.1124	79.81439	78.47148	78.633

0.03459	82.50812	81.62157	81.88046	85.02397	80.24663	79.8633	78.81735	78.69482
0.03468	82.38127	81.64476	81.77582	84.84074	80.19674	79.81469	78.81196	78.743
0.03478	82.11666	81.39285	81.47788	84.49328	80.01797	79.64375	78.42693	78.57881
0.03487	81.71784	81.13748	81.21183	84.05727	79.779	79.48059	78.04875	78.32317
0.03496	81.24453	80.84936	80.94083	83.5662	79.42274	79.1432	77.63082	77.99999
0.03505	81.00879	80.57253	80.69335	83.20924	79.09003	78.79226	77.26459	77.69759
0.03514	81.0213	80.50419	80.56332	83.23958	79.04242	78.82224	77.27203	77.75596
0.03524	80.98588	80.50764	80.46786	83.42219	79.07251	78.96977	77.43203	77.74567
0.03533	80.93088	80.43635	80.44815	83.46376	79.03935	79.01161	77.51703	77.6811
0.03542	81.03523	80.50907	80.58241	83.43425	79.0932	79.08323	77.67381	77.75585
0.03551	81.12081	80.62541	80.72947	83.41607	79.27425	79.17208	77.82931	77.84233
0.0356	80.94127	80.4991	80.74723	83.25653	79.23367	79.09857	77.74529	77.74047
0.0357	80.85186	80.35275	80.75672	83.21752	79.18922	78.99886	77.62181	77.79619
0.03579	80.95429	80.37197	80.9076	83.39155	79.27039	79.0397	77.67508	78.0223
0.03588	81.07782	80.44856	80.86178	83.67773	79.32919	79.1169	77.84752	77.9621
0.03597	81.04815	80.55402	80.67519	83.80847	79.34968	79.00782	77.83048	77.9072
0.03606	80.91493	80.46676	80.51884	83.62023	79.29732	78.79305	77.58166	77.85333
0.03616	81.02776	80.39394	80.55476	83.43036	79.24238	78.84426	77.44045	77.86657
0.03625	81.18953	80.53002	80.75187	83.35652	79.34463	79.08173	77.64139	77.95171
0.03634	81.17248	80.60273	80.8174	83.39911	79.49817	79.21691	77.86583	78.02494
0.03643	80.90383	80.44652	80.61523	83.18494	79.36196	79.10664	77.6507	77.82929
0.03652	80.66294	80.29702	80.38489	82.97341	79.123	78.859	77.43536	77.51049
0.03662	80.34858	79.97199	80.01069	82.61339	78.76228	78.52211	77.16137	77.18915
0.03671	80.13	79.73065	79.85073	82.50574	78.65814	78.30704	76.96377	77.15259
0.0368	80.10043	79.71834	79.97343	82.63392	78.76079	78.36272	76.97219	77.17459
0.03689	80.07762	79.70421	79.88778	82.48879	78.72664	78.42279	76.90276	77.08038
0.03698	80.14231	79.67441	79.62782	82.31168	78.56786	78.45905	76.79299	76.87515
0.03708	80.20397	79.72943	79.55619	82.24295	78.49985	78.48923	76.81159	76.78888
0.03717	80.16239	79.6083	79.508	82.11262	78.41601	78.33184	76.70505	76.7628
0.03726	79.92846	79.43033	79.36899	81.94063	78.37186	78.01477	76.58157	76.69253
0.03735	79.70917	79.42351	79.29355	81.98976	78.39344	77.84683	76.63465	76.62266
0.03744	79.82088	79.61756	79.4275	82.22436	78.59647	78.03161	76.8208	76.81587
0.03754	79.98831	79.7936	79.61956	82.5275	78.82939	78.33493	77.0091	77.0929
0.03763	80.16481	79.92754	79.7949	82.724	78.88968	78.48854	77.07589	77.3239

Table 9-2 Atmospheric residue + pentane, X-ray intensity profile, free diffusion

Elevation(m)	t=0 s	t=3420 s	t=6780 s	t=14820 s	t=25980 s
0.00E+00	38.42736	38.23326	38.23136	38.19268	38.39597
9.20E-05	38.35794	38.25835	38.19348	38.31319	38.43657
1.84E-04	38.38773	38.43759	38.22292	38.42717	38.4702
2.76E-04	38.50413	38.65033	38.23872	38.5026	38.54153
3.68E-04	38.42736	38.76075	38.21988	38.49686	38.57615
4.60E-04	38.42736	38.78633	38.29378	38.52791	38.62624
5.52E-04	38.35794	38.73739	38.3458	38.51515	38.57605
6.44E-04	38.38773	38.76152	38.49478	38.55341	38.61476
7.36E-04	38.50413	38.87088	38.6579	38.63022	38.76691
8.28E-04	38.59147	38.9733	38.69117	38.74787	38.79864
9.20E-04	38.69398	38.95602	38.66722	38.80738	38.75614
0.00101	38.67798	38.94057	38.74171	38.94667	38.78118
0.0011	38.6812	38.87552	38.82513	39.03969	38.88195
0.0012	38.73876	38.86162	38.88265	38.97919	38.96585
0.00129	38.7155	38.83585	38.8218	38.91068	39.07121
0.00138	38.67385	39.01412	38.77852	39.0221	39.26247
0.00147	38.79806	39.14125	38.80197	39.08428	39.27155
0.00156	38.97155	39.09231	38.84368	39.01864	39.23823
0.00166	39.03986	39.09308	38.80943	38.9784	39.0318
0.00175	39.03949	39.15003	38.74397	38.97484	38.86668
0.00184	39.03784	39.11953	38.83779	38.98107	38.92645
0.00193	39.05199	39.10071	39.01367	38.98196	39.08249
0.00202	38.9926	39.11451	39.15784	39.05472	39.20909
0.00212	38.97614	39.14848	39.24588	39.20943	39.29569
0.00221	38.988	39.23815	39.25196	39.34863	39.31405
0.0023	39.03765	39.36122	39.36041	39.35495	39.32832
0.00239	39.16701	39.46633	39.49095	39.31561	39.39417
0.00248	39.28	39.53448	39.61107	39.42504	39.54771
0.00258	39.36257	39.58033	39.70107	39.58717	39.60269
0.00267	39.36036	39.5616	39.70362	39.67377	39.64669
0.00276	39.42977	39.54461	39.68969	39.7233	39.73478
0.00285	39.5778	39.54037	39.61834	39.58717	39.68969
0.00294	39.66661	39.56237	39.51028	39.40112	39.55819
0.00304	39.64418	39.59567	39.55081	39.4374	39.53415
0.00313	39.62708	39.52154	39.46032	39.43285	39.42799
0.00322	39.5903	39.44114	39.35727	39.40419	39.47309
0.00331	39.47253	39.47241	39.29603	39.33172	39.53963
0.0034	39.4568	39.36354	39.20063	39.23079	39.37332
0.0035	39.49303	39.29539	39.16403	39.33696	39.35995
0.00359	39.38518	39.55562	39.32763	39.58233	39.66684
0.00368	39.40569	39.74625	39.4089	39.55247	39.61436
0.00377	39.51693	39.69895	39.41135	39.51184	39.48745
0.00386	39.43704	39.45282	39.30162	39.49326	39.37731
0.00396	39.41626	39.42801	39.39398	39.62701	39.44196

0.00405	39.59499	39.43979	39.42195	39.59706	39.47877
0.00414	39.61568	39.51595	39.44079	39.53557	39.56468
0.00423	39.56116	39.62425	39.40566	39.46884	39.57056
0.00432	39.4785	39.53274	39.24441	39.39321	39.45682
0.00442	39.60924	39.62946	39.29574	39.64036	39.47788
0.00451	39.62128	39.72424	39.44295	39.77619	39.56318
0.0046	39.61365	39.65919	39.60018	39.7236	39.62075
0.00469	39.59793	39.56826	39.68802	39.64036	39.67991
0.00478	39.50121	39.52164	39.77841	39.60724	39.74167
0.00488	39.49698	39.68969	39.91267	39.77658	39.95737
0.00497	39.59012	39.92684	39.90983	39.95858	40.10962
0.00506	39.69033	40.20039	39.97548	40.13979	40.23483
0.00515	39.73768	40.31516	39.9852	40.22461	40.34797
0.00524	39.68969	40.34006	39.82572	40.21107	40.21288
0.00534	39.8093	40.22076	39.68036	40.11735	40.03569
0.00543	39.96808	40.03891	39.81188	40.02689	40.06383
0.00552	40.16327	39.97501	39.98245	40.07929	40.10154
0.00561	40.2907	40.07964	40.11544	40.13623	40.12618
0.0057	40.29244	40.13244	40.11141	40.06436	40.09446
0.0058	40.2074	40.07896	39.99315	40.16747	40.04247
0.00589	40.12824	39.93254	39.85202	40.16322	39.95817
0.00598	40.01469	39.75899	39.75809	40.01355	39.8163
0.00607	39.91411	39.75349	39.83671	39.78113	39.70535
0.00616	39.81767	39.83515	39.83082	39.69008	39.69468
0.00626	39.79367	39.82656	39.73238	39.68969	39.75015
0.00635	39.87375	39.81719	39.7686	39.86872	39.87656
0.00644	39.94317	39.94663	39.90462	40.02699	40.01883
0.00653	39.98408	40.11217	39.9798	40.02501	40.07889
0.00662	39.9622	40.24112	40.06195	40.11418	40.17956
0.00672	39.96725	40.33292	40.20642	40.37833	40.39496
0.00681	39.95659	40.22278	40.20377	40.44862	40.38878
0.0069	39.99382	40.18012	40.14537	40.41007	40.27853
0.00699	40.15757	40.18417	40.05263	40.1298	40.09705
0.00708	40.36737	40.24479	40.09826	40.06406	40.17018
0.00718	40.55916	40.37432	40.18463	40.31833	40.36274
0.00727	40.44975	40.54884	40.23468	40.56508	40.51439
0.00736	40.32177	40.808	40.38426	40.67916	40.65736
0.00745	40.11757	40.84333	40.60577	40.68667	40.67352
0.00754	40.17145	40.84729	40.75868	40.60937	40.65028
0.00764	40.39615	40.78947	40.72599	40.51179	40.66803
0.00773	40.65836	40.66013	40.58339	40.3896	40.58952
0.00782	40.89134	40.58687	40.47052	40.39524	40.56757
0.00791	40.9009	40.57162	40.49594	40.39257	40.49872
0.008	40.7172	40.52722	40.4613	40.44506	40.5521
0.0081	40.63005	40.50772	40.43539	40.5286	40.62763
0.00819	40.56688	40.59362	40.63227	40.60403	40.78836
0.00828	40.54951	40.5999	40.68232	40.63013	40.8139
0.00837	40.60311	40.64632	40.66308	40.69211	40.79734

0.00846	40.56403	40.72287	40.66092	40.82142	40.90569
0.00856	40.52799	40.78966	40.78586	40.89833	40.96046
0.00865	40.65257	40.77306	40.82865	40.82764	40.83246
0.00874	40.53599	40.73445	40.80961	40.82063	40.8572
0.00883	40.47228	40.75375	40.82689	40.8312	41.04706
0.00892	40.61304	40.86331	40.76123	40.90001	41.17078
0.00902	40.76428	40.85752	40.63541	40.93263	41.118
0.00911	40.6272	40.80626	40.61058	40.85878	41.08477
0.0092	40.70461	40.77412	40.62873	40.69636	40.90958
0.00929	40.89722	40.65964	40.45266	40.52346	40.64938
0.00938	41.04589	40.64015	40.48613	40.5892	40.58423
0.00948	41.07182	40.8303	40.72786	40.80609	40.76262
0.00957	41.0583	40.9746	40.9108	40.8921	41.09086
0.00966	40.98144	41.03039	40.98873	40.97662	41.25688
0.00975	40.6682	40.88763	40.79205	41.00144	41.1625
0.00984	40.54712	40.8579	40.78243	41.08388	41.2025
0.00994	40.7207	40.94217	40.96242	41.17899	41.423
0.01003	40.89198	41.0552	41.0747	41.20726	41.49064
0.01012	40.97427	41.10529	41.05203	41.26746	41.31804
0.01021	40.97611	41.25606	41.04094	41.35515	41.29968
0.0103	41.04203	41.2883	41.08324	41.33657	41.47278
0.0104	41.16587	41.34254	41.24901	41.54793	41.69098
0.01049	41.24429	41.3632	41.38386	41.64332	41.79574
0.01058	41.2807	41.26812	41.29631	41.3685	41.67152
0.01067	41.34203	41.30393	41.11877	41.16386	41.59979
0.01076	41.25974	41.32961	40.97518	41.13618	41.61206
0.01086	41.29275	41.16417	40.85545	41.05225	41.59071
0.01095	41.41493	41.10346	40.84553	40.98859	41.58752
0.01104	41.29541	41.21591	40.93897	41.11611	41.62124
0.01113	41.25652	41.25094	40.96262	41.23158	41.63321
0.01122	41.17534	41.29322	40.97155	41.42682	41.77628
0.01132	41.03191	41.2604	41.02013	41.68089	41.91796
0.01141	41.02594	41.16089	40.99825	41.7925	42.00396
0.0115	40.99643	41.16967	41.07146	41.80555	42.24071
0.01159	40.95956	41.0995	41.06322	41.61545	42.33539
0.01168	41.01178	41.01803	41.10532	41.62009	42.48934
0.01178	41.13718	41.10201	41.37865	41.84045	42.76161
0.01187	41.15116	41.15066	41.42311	42.02007	43.07948
0.01196	41.15566	41.38472	41.44147	42.26603	43.43127
0.01205	41.02392	41.65431	41.63962	42.43449	43.68219
0.01214	40.93216	41.73375	41.84062	42.53305	43.91655
0.01224	41.07494	41.8628	42.1802	42.89843	44.49372
0.01233	41.17304	41.92525	42.31799	43.28595	45.03298
0.01242	41.26884	42.02168	42.35951	43.62849	45.48364
0.01251	41.26829	42.08249	42.52213	43.92981	46.00684
0.0126	41.22922	42.271	42.95603	44.43093	46.52834
0.0127	41.48867	42.48808	43.28354	44.82171	46.86915
0.01279	41.75713	42.74676	43.58494	45.17029	47.35374

0.01288	41.83501	42.87928	43.85356	45.58203	47.98758
0.01297	41.87307	42.96606	44.211	46.22283	48.68567
0.01306	41.93586	42.9899	44.44871	46.61431	49.23869
0.01316	42.00013	43.3175	44.91941	47.11186	49.99096
0.01325	42.17831	43.46624	45.3326	47.53122	50.44791
0.01334	42.42747	43.58892	45.54685	47.94613	50.75979
0.01343	42.61907	43.88244	45.97986	48.52118	51.38505
0.01352	42.55738	44.25271	46.70259	49.16762	52.13592
0.01362	42.61006	44.75984	47.46684	49.74228	52.82384
0.01371	42.66706	45.25616	48.10361	50.31615	53.4461
0.0138	42.74732	45.60953	48.55919	50.93224	53.81266
0.01389	42.98692	45.95749	49.0454	51.57561	54.1436
0.01398	43.17025	46.44686	49.57528	52.1822	54.48052
0.01408	43.26283	46.99386	50.30361	52.84672	55.0994
0.01417	43.42041	47.62589	50.94498	53.46568	55.71568
0.01426	43.48339	48.29807	51.64073	54.156	56.1388
0.01435	43.55593	49.22739	52.5148	55.01953	56.7033
0.01444	43.70248	50.14822	53.42607	55.83224	57.32946
0.01454	43.86742	50.79348	54.16461	56.52712	57.89206
0.01463	43.8985	51.57463	54.83425	57.16347	58.4842
0.01472	44.0114	52.50627	55.63108	57.72162	59.08432
0.01481	44.4186	53.63829	56.60075	58.34808	59.75128
0.0149	44.8258	54.52399	57.34223	58.98355	60.15366
0.015	45.25746	55.27995	57.97821	59.65044	60.60422
0.01509	45.87345	56.20425	58.59141	60.29915	61.18648
0.01518	46.42601	57.3051	59.40621	60.96684	61.92877
0.01527	47.04302	58.26733	60.16113	61.6193	62.51103
0.01536	47.62647	59.22889	61.0885	62.38605	63.04081
0.01546	48.43232	60.17395	61.99163	63.23969	63.71785
0.01555	49.38435	61.01514	62.68433	63.85399	64.31786
0.01564	50.63096	61.99765	63.41374	64.52544	65.00289
0.01573	52.11055	63.14974	64.25935	65.2992	65.67115
0.01582	53.96092	64.19316	64.95755	65.78024	66.2558
0.01592	56.01825	65.17643	65.71817	66.33533	66.90491
0.01601	58.03449	65.95962	66.59734	67.19945	67.63183
0.0161	60.3316	66.73865	67.40586	68.18111	68.41553
0.01619	62.73693	67.68612	68.11161	69.01024	69.05715
0.01628	65.0059	68.7471	68.93779	69.66428	69.73419
0.01638	67.1504	69.68144	69.75858	70.18527	70.28073
0.01647	69.36191	70.69522	70.63471	71.00836	71.00845
0.01656	71.56791	71.87811	71.75856	71.99892	71.89831
0.01665	73.72638	72.98406	72.88869	72.85078	72.69617
0.01674	75.68423	74.06502	73.88515	73.74634	73.3753
0.01684	77.26991	75.41345	74.9302	74.75528	74.30636
0.01693	78.8304	76.7027	75.8398	75.72449	75.18773
0.01702	80.46132	77.70316	76.69935	76.60472	75.92443
0.01711	81.91479	78.6737	77.61994	77.464	76.68019
0.0172	83.0975	79.59703	78.48518	78.19614	77.33608

0.0173	84.32058	80.60521	79.36328	78.91118	78.04016
0.01739	85.45759	81.61687	80.11664	79.57521	78.81009
0.01748	86.3723	82.48982	80.74407	80.19377	79.45271
0.01757	87.07803	83.38719	81.57006	80.95458	80.21804
0.01766	87.6168	84.35319	82.52235	81.79547	81.05751
0.01776	88.23399	85.24806	83.36845	82.63319	81.78912
0.01785	88.84833	85.80268	83.88636	83.14795	82.11787
0.01794	89.31216	86.40768	84.35834	83.68346	82.51944
0.01803	89.76919	87.14811	85.00393	84.23134	83.09063
0.01812	90.34078	87.8394	85.67661	84.76309	83.74951
0.01822	90.88231	88.27376	86.0847	85.11602	84.20516
0.01831	91.15371	88.70927	86.49219	85.63057	84.58778
0.0184	91.41455	89.03397	86.6291	85.83066	84.8395
0.01849	91.66444	89.4106	86.87152	86.13475	85.27899
0.01858	91.98301	89.68569	87.28098	86.55727	85.71039
0.01868	92.12552	89.84505	87.67473	86.94776	86.07116
0.01877	92.23033	90.11155	88.20481	87.40785	86.4443
0.01886	92.19815	90.28626	88.62713	87.71213	86.78163
0.01895	92.39196	90.47573	88.86817	87.88345	87.06647
0.01904	92.69104	90.79638	89.0942	88.17894	87.39621
0.01914	92.87905	91.08778	89.27066	88.56646	87.70759
0.01923	93.10752	91.13807	89.42779	88.76883	87.80407
0.01932	93.23651	91.29531	89.64979	88.99413	87.91192
0.01941	93.21656	91.59626	89.98829	89.32817	88.23977
0.0195	93.26685	91.55447	89.94648	89.26974	88.24885
0.0196	93.37203	91.41837	89.79554	89.18057	88.12324
0.01969	93.35079	91.40602	89.93971	89.37236	88.35829
0.01978	93.44007	91.62059	90.46969	89.86863	88.95482
0.01987	93.62514	91.9589	90.9823	90.28195	89.49358
0.01996	93.44163	92.08882	91.08977	90.3733	89.69711
0.02006	93.18567	91.99857	90.8658	90.15225	89.52621
0.02015	93.21868	92.00764	90.77286	90.13436	89.41287
0.02024	93.43667	92.13226	90.9874	90.43103	89.63146
0.02033	93.65098	92.26758	91.26309	90.73294	89.97028
0.02042	93.70522	92.23969	91.22717	90.83872	89.9612
0.02052	93.54828	92.15368	91.09065	90.79354	89.93935
0.02061	93.40357	92.0533	90.99182	90.62647	89.91531
0.0207	93.44788	92.05369	91.05002	90.67551	89.93197
0.02079	93.55508	92.14866	91.23512	90.91059	89.98774
0.02088	93.45423	92.34702	91.52543	91.22565	90.17112
0.02098	93.35208	92.57153	91.72486	91.48901	90.49946
0.02107	93.23504	92.77828	91.90064	91.64837	90.76675
0.02116	93.19634	92.77635	91.95952	91.62721	90.85395
0.02125	93.21868	92.88127	92.04795	91.76018	91.07055
0.02134	93.3371	92.99749	92.21215	91.94405	91.36597
0.02144	93.47004	93.08262	92.39509	92.03006	91.56601
0.02153	93.56667	93.10395	92.43739	92.10836	91.56331
0.02162	93.53265	93.10125	92.40539	92.19505	91.55483

0.02171	93.64951	93.10627	92.43523	92.25239	91.52241
0.0218	93.80488	93.06843	92.29086	92.04173	91.37994
0.0219	93.86556	92.89623	92.10487	91.80397	91.24904
0.02199	93.76066	92.84208	92.13638	91.85518	91.33474
0.02208	93.65888	92.90473	92.27879	92.02878	91.4373
0.02217	93.6085	92.96698	92.3202	92.13198	91.51931
0.02226	93.4534	93.06023	92.36319	92.24043	91.65101
0.02236	93.20259	93.24468	92.59599	92.43568	91.97716
0.02245	93.15864	93.29989	92.64516	92.46474	92.1348
0.02254	93.23587	93.46273	92.76136	92.65366	92.3078
0.02263	93.30896	93.50703	92.90779	92.79542	92.351
0.02272	93.33075	93.5024	93.04529	92.85276	92.36577
0.02282	93.47381	93.3912	92.95078	92.82182	92.32496
0.02291	93.48264	93.24111	92.72878	92.76191	92.22259
0.023	93.50663	93.02162	92.40235	92.47423	92.02186
0.02309	93.56989	93.06177	92.42561	92.41205	91.97317
0.02318	93.61365	93.24159	92.60894	92.57368	92.07823
0.02328	93.54984	93.09642	92.47223	92.47018	91.96928
0.02337	93.34758	92.84894	92.21862	92.31013	91.84566
0.02346	93.0051	92.64634	92.19104	92.17439	91.76295
0.02355	92.95058	92.61979	92.23815	92.17044	91.7841
0.02364	93.07718	92.63997	92.1934	92.15858	91.76425
0.02374	92.97384	92.5975	92.09584	92.14345	91.71756
0.02383	92.76339	92.58138	92.09074	92.28264	91.79149
0.02392	92.58052	92.57829	92.15247	92.3474	91.86871
0.02401	92.52251	92.51284	92.15974	92.30667	91.85165
0.0241	92.45199	92.40136	92.0876	92.22264	91.69521
0.0242	92.3949	92.26121	91.90888	92.08443	91.61769
0.02429	92.45779	92.20339	91.75921	92.0093	91.66677
0.02438	92.58365	92.30966	91.83576	92.09323	91.69601
0.02447	92.53768	92.32781	92.02283	92.17855	91.67116
0.02456	92.33587	92.32279	92.07661	92.20899	91.75038
0.02466	92.15871	92.25735	91.95569	92.15215	91.72075
0.02475	92.063	92.12897	91.75793	91.99684	91.62178
0.02484	92.1416	92.12173	91.74812	92.0181	91.71726
0.02493	92.14657	92.21623	91.96845	92.21601	91.90373
0.02502	92.09894	92.25185	92.13285	92.38921	92.00559
0.02512	91.97308	92.28158	92.17308	92.43577	92.06965
0.02521	91.86036	92.16285	91.98965	92.15264	91.9613
0.0253	91.88022	92.12743	91.87738	91.90837	91.80166
0.02539	92.00857	92.2227	91.9501	92.11824	91.89275
0.02548	92.10005	92.42511	92.15228	92.37577	92.14308
0.02558	92.10354	92.47453	92.26799	92.46296	92.25702
0.02567	91.89723	92.43843	92.2462	92.46622	92.23367
0.02576	91.76355	92.29972	92.11165	92.30785	92.10078
0.02585	91.83011	92.08206	91.90446	92.19921	91.99572
0.02594	91.97786	91.94886	91.80553	92.14058	91.90044
0.02604	92.04893	91.87319	91.76539	92.13445	91.76944

0.02613	92.10198	91.8063	91.71328	92.08008	91.64732
0.02622	92.04111	91.84394	91.85235	92.1394	91.77113
0.02631	91.83195	91.80823	91.86314	92.10509	91.84337
0.0264	91.68834	91.64288	91.75479	91.99635	91.7417
0.0265	91.5942	91.54028	91.71465	91.95819	91.60851
0.02659	91.44866	91.52001	91.6061	91.96491	91.62637
0.02668	91.52092	91.5147	91.48568	91.92191	91.67107
0.02677	91.57406	91.44405	91.40864	91.80783	91.67326
0.02686	91.37474	91.27745	91.26132	91.65213	91.51682

9.3 Mass Fraction Profile Data

Table 9-3Bitumen + pentane, mass fraction profile, free diffusion

Elevation (m)	t=0 s	t=3960 s	t=9840 s	t=20220 s	t=82860 s	t=111180 s	t=168840 s	t=186480 s
3.68E-04	-7.11E-05	0.00193	5.11E-04	6.49E-04	0.00113	1.27E-04	-0.0032	-0.00717
4.60E-04	3.56E-04	0.00233	5.16E-04	0.00116	0.00142	1.26E-04	-0.00299	-0.00648
5.52E-04	0.0012	0.00301	0.00132	0.00236	0.00259	9.17E-04	-0.00228	-0.00506
6.44E-04	0.00146	0.00307	0.00194	0.00305	0.00304	0.0013	-0.00167	-0.00354
7.36E-04	0.00113	0.00286	0.00223	0.00325	0.0029	0.00131	-0.00157	-0.00243
8.28E-04	8.73E-04	0.00259	0.00236	0.00315	0.00244	0.00115	-0.00155	-0.00178
9.20E-04	0.00123	0.00207	0.0025	0.0029	0.00172	8.15E-04	-0.00101	-0.00115
0.00101	0.00185	0.00159	0.00245	0.00252	0.00113	9.45E-04	-9.15E-05	-3.75E-04
0.0011	0.00207	0.00147	0.0024	0.002	6.45E-04	0.00128	0.00108	3.97E-04
0.0012	0.0022	0.00179	0.00269	0.00181	2.86E-04	0.00149	0.00251	0.0014
0.00129	0.0016	0.00166	0.00237	0.00101	-0.00103	0.00107	0.00341	0.00171
0.00138	5.95E-04	0.00122	0.00141	-9.07E-04	-0.00292	6.93E-05	0.0035	0.00141
0.00147	4.62E-04	0.00102	6.70E-04	-0.00268	-0.00387	-5.18E-04	0.00371	0.00118
0.00156	0.00101	9.67E-04	3.09E-04	-0.00382	-0.00404	-9.53E-04	0.00399	0.00106
0.00166	0.00131	7.09E-04	3.30E-04	-0.00427	-0.00388	-0.00131	0.00384	0.00119
0.00175	0.00133	4.67E-04	5.86E-04	-0.00449	-0.00334	-0.00152	0.00338	0.00141
0.00184	0.00163	5.87E-04	9.18E-04	-0.00441	-0.00264	-0.00212	0.0029	0.00197
0.00193	0.00242	7.57E-04	0.00116	-0.00355	-0.00164	-0.00235	0.0026	0.00261
0.00202	0.00304	-1.56E-04	8.52E-04	-0.00301	-8.10E-04	-0.00225	0.00216	0.00272
0.00212	0.00329	-0.00123	6.47E-04	-0.0024	-1.59E-05	-0.00244	0.00188	0.00306
0.00221	0.00343	-0.00197	3.12E-04	-0.00134	5.33E-04	-0.00305	0.00172	0.00344
0.0023	0.00323	-0.00226	-1.24E-04	-1.15E-04	7.71E-04	-0.00349	0.00157	0.00417
0.00239	0.00267	-0.00206	-4.32E-04	8.10E-04	6.94E-04	-0.00323	0.0021	0.00561
0.00248	0.00219	-0.00169	-8.16E-04	0.0012	5.87E-04	-0.00262	0.00357	0.00721
0.00258	0.00175	-0.0018	-0.00156	0.00105	1.72E-04	-0.00282	0.00489	0.00859
0.00267	0.00108	-0.00218	-0.00219	9.86E-04	-4.18E-04	-0.00296	0.00556	0.01007
0.00276	-1.70E-04	-0.00268	-0.0028	6.02E-04	-0.0016	-0.00346	0.00535	0.01167
0.00285	-0.00143	-0.00224	-0.00288	1.04E-04	-0.00219	-0.00385	0.00527	0.01394
0.00294	-0.00217	-0.00145	-0.00276	-3.56E-04	-0.00204	-0.00386	0.00545	0.01718
0.00304	-0.0026	-8.10E-04	-0.00246	-6.64E-04	-0.00152	-0.00392	0.00609	0.02088
0.00313	-0.00294	-6.68E-04	-0.00196	-0.00112	-9.36E-04	-0.00397	0.0071	0.02464
0.00322	-0.00337	-0.00151	-0.00188	-0.00172	-7.31E-04	-0.0043	0.00796	0.02844
0.00331	-0.00386	-0.00252	-0.00213	-0.00238	-7.45E-04	-0.00458	0.00876	0.03232
0.0034	-0.00447	-0.00277	-0.00205	-0.00281	-7.86E-04	-0.00381	0.01022	0.03662
0.0035	-0.00493	-0.00275	-0.00168	-0.00346	-0.00111	-0.00274	0.01237	0.04076
0.00359	-0.00499	-0.00295	-0.00143	-0.00403	-7.95E-04	-0.00177	0.01563	0.04489
0.00368	-0.00486	-0.00351	-0.00117	-0.00385	-2.28E-04	-8.43E-04	0.02029	0.04969
0.00377	-0.00471	-0.00376	-4.37E-04	-0.00306	4.13E-04	7.69E-04	0.02623	0.05473
0.00386	-0.00456	-0.00404	5.49E-04	-0.00236	8.84E-04	0.00319	0.03293	0.06008
0.00396	-0.004	-0.00408	0.00108	-0.0021	9.62E-04	0.00534	0.0396	0.06576

0.00405	-0.00316	-0.00361	9.63E-04	-0.00223	0.0011	0.00714	0.04566	0.07109
0.00414	-0.00229	-0.00319	6.11E-04	-0.00221	0.00151	0.00854	0.05117	0.07616
0.00423	-0.00126	-0.00311	5.67E-04	-0.0013	0.00252	0.00976	0.05665	0.08124
0.00432	-2.94E-04	-0.00319	9.04E-04	4.49E-04	0.00404	0.01111	0.06245	0.08681
0.00442	4.49E-04	-0.00263	0.00177	0.00203	0.00534	0.01238	0.06858	0.09308
0.00451	9.81E-04	-0.00177	0.00223	0.00235	0.00571	0.01319	0.07393	0.0992
0.0046	0.00131	-0.00164	0.00196	0.00223	0.00539	0.01358	0.07842	0.105
0.00469	0.00207	-0.00155	0.00169	0.00281	0.00542	0.01432	0.08249	0.11086
0.00478	0.00261	-0.00142	0.00141	0.00388	0.00612	0.01552	0.08618	0.11635
0.00488	0.00301	-0.00128	0.00147	0.00495	0.00732	0.01673	0.09037	0.12183
0.00497	0.00365	-5.67E-04	0.00217	0.00633	0.00886	0.01805	0.09568	0.12761
0.00506	0.00433	6.44E-04	0.00323	0.00732	0.0103	0.01916	0.1016	0.13357
0.00515	0.0045	0.00177	0.00375	0.00713	0.01128	0.02002	0.10686	0.13932
0.00524	0.00426	0.00209	0.00353	0.00638	0.01167	0.02158	0.11128	0.14485
0.00534	0.00386	0.00152	0.00337	0.00621	0.01177	0.0235	0.11559	0.14986
0.00543	0.00345	9.50E-04	0.00331	0.0062	0.01184	0.0253	0.11985	0.15456
0.00552	0.00283	7.22E-04	0.00326	0.00565	0.01171	0.02687	0.12417	0.15891
0.00561	0.00261	9.78E-04	0.00371	0.00544	0.01133	0.02903	0.12948	0.16337
0.0057	0.0024	0.00146	0.00444	0.00604	0.0111	0.032	0.13505	0.1679
0.0058	0.00152	0.00143	0.0049	0.0062	0.01091	0.03557	0.13963	0.17196
0.00589	4.21E-04	5.72E-04	0.00438	0.00547	0.01031	0.03966	0.14351	0.17568
0.00598	7.99E-05	-3.51E-04	0.00393	0.00501	0.01015	0.0445	0.1482	0.17954
0.00607	1.75E-04	-8.54E-04	0.00388	0.00478	0.01075	0.04956	0.15351	0.18334
0.00616	5.04E-04	-8.64E-04	0.00404	0.00453	0.01234	0.05505	0.15863	0.18701
0.00626	0.00106	-6.22E-04	0.00439	0.00415	0.01469	0.06088	0.1637	0.19061
0.00635	0.00175	-3.40E-04	0.00447	0.00449	0.01725	0.06689	0.16868	0.19404
0.00644	0.0022	-2.88E-04	0.00387	0.00522	0.02014	0.0728	0.1733	0.19715
0.00653	0.00285	-7.83E-05	0.00344	0.00573	0.02261	0.07863	0.17779	0.20062
0.00662	0.00394	2.92E-04	0.00359	0.00581	0.02456	0.08462	0.18271	0.20479
0.00672	0.00545	0.00166	0.0044	0.00654	0.02752	0.09125	0.18818	0.2097
0.00681	0.00628	0.00318	0.00459	0.00731	0.03106	0.09738	0.19322	0.21454
0.0069	0.00647	0.00393	0.00395	0.00798	0.03455	0.10282	0.1977	0.21864
0.00699	0.00641	0.00441	0.00321	0.00893	0.03801	0.10801	0.20227	0.22251
0.00708	0.00641	0.00497	0.00305	0.01025	0.04214	0.11359	0.20698	0.22668
0.00718	0.00681	0.00559	0.00382	0.01125	0.04735	0.11981	0.21204	0.23165
0.00727	0.00789	0.00625	0.00546	0.01178	0.05313	0.12629	0.21734	0.23703
0.00736	0.00944	0.00689	0.00713	0.01198	0.05957	0.13321	0.22274	0.24203
0.00745	0.01056	0.00762	0.00836	0.01199	0.06691	0.14037	0.22807	0.24675
0.00754	0.01088	0.00801	0.00905	0.01177	0.07454	0.14717	0.23274	0.25112
0.00764	0.01086	0.00819	0.00967	0.01212	0.08187	0.15404	0.23702	0.25529
0.00773	0.0107	0.00855	0.01061	0.01267	0.08905	0.1608	0.24131	0.25957
0.00782	0.0105	0.00931	0.01155	0.01278	0.09634	0.16771	0.24577	0.26411
0.00791	0.01022	0.00978	0.01157	0.01235	0.10318	0.17432	0.25027	0.26838
0.008	0.00963	0.0096	0.01078	0.01173	0.10911	0.18009	0.25435	0.27189
0.0081	0.0082	0.00874	0.00964	0.01067	0.11457	0.18553	0.25774	0.27514
0.00819	0.00667	0.0079	0.00861	0.00999	0.12034	0.19055	0.26105	0.27872
0.00828	0.00582	0.00749	0.00806	0.01069	0.12629	0.19552	0.26448	0.28256
0.00837	0.00504	0.00706	0.00788	0.01141	0.13171	0.20057	0.26791	0.28573

0.00846	0.00442	0.00626	0.008	0.01099	0.13702	0.20548	0.27154	0.2883
0.00856	0.005	0.00566	0.00853	0.01093	0.14305	0.21087	0.27537	0.2911
0.00865	0.00642	0.00531	0.00953	0.01169	0.14981	0.21629	0.27938	0.29436
0.00874	0.00802	0.00506	0.01104	0.01261	0.15692	0.22139	0.28339	0.29778
0.00883	0.00926	0.00508	0.01269	0.01382	0.16473	0.22681	0.28743	0.30166
0.00892	0.01022	0.00535	0.01391	0.01522	0.1728	0.23209	0.29148	0.30541
0.00902	0.01108	0.0054	0.0144	0.0166	0.18053	0.23723	0.29528	0.30882
0.00911	0.01198	0.00495	0.01457	0.01785	0.18747	0.24215	0.29904	0.31206
0.0092	0.01327	0.00431	0.01459	0.01922	0.194	0.24696	0.30286	0.31569
0.00929	0.0149	0.00443	0.01479	0.02095	0.20052	0.25222	0.30664	0.31977
0.00938	0.01613	0.0054	0.01547	0.02222	0.20728	0.25766	0.31091	0.32392
0.00948	0.01662	0.00615	0.01632	0.02325	0.21404	0.2632	0.31514	0.32764
0.00957	0.01615	0.00662	0.01711	0.02432	0.22033	0.26865	0.31926	0.33107
0.00966	0.01536	0.00692	0.01771	0.02438	0.22597	0.27327	0.32301	0.3343
0.00975	0.01505	0.00787	0.01859	0.02471	0.23162	0.27805	0.32703	0.33796
0.00984	0.01445	0.00886	0.02008	0.02526	0.23741	0.28324	0.33115	0.34167
0.00994	0.01325	0.0095	0.02086	0.02539	0.24334	0.28822	0.33484	0.34484
0.01003	0.01187	0.01021	0.02076	0.02532	0.24913	0.29278	0.3383	0.34783
0.01012	0.01062	0.0113	0.02064	0.02565	0.25506	0.29682	0.34205	0.35126
0.01021	0.00947	0.0123	0.0208	0.02665	0.26084	0.30086	0.34572	0.35497
0.0103	0.00919	0.01347	0.02098	0.0282	0.26618	0.30523	0.34898	0.3589
0.0104	0.01055	0.01541	0.02139	0.03045	0.27162	0.31025	0.35196	0.36313
0.01049	0.0124	0.01725	0.02188	0.03346	0.27692	0.31602	0.35525	0.36731
0.01058	0.0141	0.01835	0.02263	0.03659	0.28214	0.32179	0.35862	0.37107
0.01067	0.0158	0.01912	0.02314	0.04015	0.28733	0.32696	0.36211	0.37456
0.01076	0.01725	0.01995	0.02423	0.04465	0.29254	0.33192	0.36594	0.37868
0.01086	0.01841	0.02045	0.02656	0.05023	0.29841	0.33659	0.36991	0.38295
0.01095	0.01952	0.0205	0.02907	0.05649	0.30438	0.34122	0.37377	0.38659
0.01104	0.02102	0.02068	0.0307	0.06336	0.30975	0.34619	0.37751	0.39
0.01113	0.0223	0.02064	0.03183	0.07049	0.31501	0.35119	0.38174	0.39338
0.01122	0.02281	0.02039	0.03312	0.07774	0.32055	0.35578	0.38615	0.39618
0.01132	0.02313	0.02105	0.03461	0.08551	0.32636	0.35971	0.39035	0.39874
0.01141	0.02307	0.02209	0.03581	0.09348	0.33167	0.36319	0.39407	0.40125
0.0115	0.02244	0.02307	0.03722	0.10178	0.33642	0.36679	0.39732	0.40389
0.01159	0.02268	0.02474	0.03959	0.11099	0.34131	0.37071	0.40063	0.40666
0.01168	0.02427	0.02754	0.04273	0.1212	0.3466	0.37526	0.40418	0.40981
0.01178	0.02638	0.03062	0.04656	0.13219	0.35244	0.38025	0.40758	0.41354
0.01187	0.02809	0.03294	0.05109	0.14313	0.35886	0.38494	0.41096	0.41757
0.01196	0.02935	0.03496	0.05639	0.15439	0.36509	0.38887	0.41404	0.4214
0.01205	0.03037	0.03686	0.06254	0.16583	0.37064	0.39247	0.41689	0.42501
0.01214	0.03128	0.03877	0.06989	0.17747	0.37581	0.39666	0.42008	0.42828
0.01224	0.03262	0.04107	0.07849	0.18996	0.38069	0.4015	0.42383	0.43161
0.01233	0.0351	0.04409	0.08829	0.20309	0.38597	0.40664	0.42788	0.43514
0.01242	0.03796	0.04712	0.09888	0.21581	0.39151	0.4115	0.43182	0.4385
0.01251	0.03977	0.04937	0.10951	0.22769	0.39656	0.41581	0.43538	0.44122
0.0126	0.04091	0.05218	0.12125	0.23942	0.40138	0.41984	0.43909	0.44326
0.0127	0.04243	0.05683	0.13439	0.25187	0.40618	0.42366	0.44267	0.44479
0.01279	0.0449	0.06297	0.14884	0.26477	0.41116	0.42812	0.44607	0.44658

0.01288	0.04798	0.06981	0.16411	0.27769	0.41598	0.43317	0.44928	0.44941
0.01297	0.05172	0.07754	0.17968	0.29082	0.42084	0.43805	0.45253	0.453
0.01306	0.05561	0.08652	0.19541	0.30393	0.4262	0.44224	0.45612	0.45691
0.01316	0.05963	0.09734	0.2113	0.31632	0.43169	0.44603	0.45993	0.46081
0.01325	0.06401	0.11008	0.22726	0.32827	0.43705	0.45011	0.4636	0.46436
0.01334	0.06913	0.1246	0.24389	0.34021	0.44219	0.45447	0.46716	0.46795
0.01343	0.0744	0.13962	0.2604	0.35109	0.44671	0.45893	0.47029	0.47187
0.01352	0.07939	0.15499	0.27682	0.36079	0.45076	0.46372	0.47347	0.47633
0.01362	0.08481	0.1716	0.29244	0.37	0.45482	0.46827	0.47696	0.48075
0.01371	0.09098	0.1893	0.30692	0.37926	0.45939	0.47241	0.48074	0.48441
0.0138	0.098	0.2075	0.32072	0.38858	0.46437	0.4764	0.48451	0.48795
0.01389	0.10607	0.22638	0.33461	0.39801	0.46967	0.4809	0.48805	0.49168
0.01398	0.11453	0.24523	0.34826	0.40738	0.47454	0.4854	0.49099	0.49532
0.01408	0.12335	0.26394	0.36137	0.41664	0.47873	0.48931	0.49371	0.49879
0.01417	0.13405	0.28346	0.37436	0.42615	0.48339	0.4934	0.497	0.50233
0.01426	0.14807	0.30385	0.38698	0.43646	0.48893	0.49768	0.50088	0.50598
0.01435	0.16566	0.32409	0.39919	0.4473	0.49482	0.50145	0.50464	0.50899
0.01444	0.18665	0.34412	0.41162	0.4578	0.50028	0.50535	0.50806	0.5122
0.01454	0.21091	0.36438	0.42455	0.4683	0.50505	0.50966	0.51148	0.51623
0.01463	0.23871	0.38483	0.43786	0.47914	0.50974	0.51431	0.51494	0.52042
0.01472	0.27047	0.40503	0.45121	0.48988	0.51464	0.51858	0.5179	0.52371
0.01481	0.30616	0.4248	0.46487	0.50069	0.52021	0.52278	0.52089	0.52623
0.0149	0.3456	0.44425	0.47858	0.5115	0.52662	0.52725	0.52422	0.52895
0.015	0.38781	0.46354	0.49207	0.52227	0.53297	0.53174	0.5281	0.53213
0.01509	0.43203	0.48271	0.5054	0.5334	0.53848	0.53659	0.53204	0.53536
0.01518	0.47742	0.50213	0.51855	0.5449	0.54361	0.54189	0.53586	0.53911
0.01527	0.52229	0.52157	0.53161	0.55685	0.54869	0.54718	0.53982	0.54271
0.01536	0.56638	0.54119	0.54498	0.56882	0.55438	0.55245	0.54412	0.546
0.01546	0.6093	0.56057	0.55867	0.58037	0.56021	0.55759	0.54825	0.54903
0.01555	0.65038	0.58011	0.57248	0.59157	0.5658	0.56288	0.55236	0.55237
0.01564	0.68935	0.59986	0.58607	0.60302	0.57128	0.56842	0.55661	0.55639
0.01573	0.72538	0.61974	0.60001	0.61542	0.57687	0.57437	0.56127	0.56064
0.01582	0.75821	0.63925	0.61449	0.62849	0.58278	0.58026	0.56559	0.56494
0.01592	0.78774	0.65852	0.6298	0.64165	0.58919	0.58577	0.56976	0.56958
0.01601	0.81405	0.6774	0.6457	0.65481	0.59579	0.59102	0.57431	0.57404
0.0161	0.83771	0.69605	0.66169	0.66771	0.60293	0.59625	0.57904	0.57881
0.01619	0.8586	0.714	0.67708	0.68058	0.61015	0.6017	0.58313	0.58354
0.01628	0.87649	0.73096	0.69174	0.69348	0.61721	0.60746	0.58682	0.58806
0.01638	0.89171	0.7466	0.70621	0.70645	0.62435	0.61311	0.59114	0.59264
0.01647	0.90496	0.76175	0.72111	0.71951	0.63158	0.61875	0.59649	0.59754
0.01656	0.91648	0.77654	0.73577	0.73189	0.63851	0.62432	0.60199	0.6026
0.01665	0.92623	0.79076	0.74926	0.74339	0.64483	0.63009	0.60704	0.60746
0.01674	0.93419	0.80429	0.76167	0.75453	0.65094	0.63604	0.61183	0.61216
0.01684	0.94057	0.81714	0.7736	0.76517	0.65747	0.64228	0.61681	0.6172
0.01693	0.94571	0.82884	0.78505	0.77554	0.66427	0.64879	0.62194	0.62207
0.01702	0.94994	0.83961	0.79606	0.78571	0.6714	0.65524	0.62741	0.62656
0.01711	0.95375	0.84986	0.80691	0.79563	0.67881	0.66151	0.6334	0.63139
0.0172	0.95738	0.86009	0.81737	0.80531	0.68615	0.66819	0.63932	0.63659

0.0173	0.96034	0.86975	0.82715	0.81457	0.69335	0.67538	0.64482	0.64206
0.01739	0.96313	0.87847	0.83621	0.82347	0.70065	0.68259	0.65043	0.64774
0.01748	0.96593	0.88612	0.84476	0.83196	0.70791	0.68986	0.65634	0.65353
0.01757	0.96869	0.89284	0.85278	0.83992	0.71532	0.69708	0.66227	0.65912
0.01766	0.97135	0.8988	0.86004	0.84756	0.72241	0.70401	0.66807	0.66427
0.01776	0.97364	0.90423	0.86648	0.85501	0.72894	0.71046	0.67384	0.6691
0.01785	0.97578	0.90926	0.87234	0.8625	0.73483	0.71656	0.67977	0.67449
0.01794	0.97761	0.91387	0.8774	0.86942	0.74031	0.7224	0.68552	0.68009
0.01803	0.97911	0.9178	0.8817	0.87555	0.74589	0.72786	0.69095	0.68558
0.01812	0.98068	0.92099	0.88529	0.88128	0.75129	0.7332	0.69608	0.69084
0.01822	0.98223	0.92365	0.88883	0.88704	0.75654	0.73852	0.70097	0.69581
0.01831	0.98366	0.92635	0.89294	0.89285	0.76226	0.74375	0.70613	0.70075
0.0184	0.98483	0.92925	0.89694	0.89838	0.76771	0.74884	0.71162	0.70591
0.01849	0.98595	0.93204	0.90064	0.90374	0.77277	0.75386	0.71695	0.71131
0.01858	0.98723	0.93434	0.90425	0.9088	0.77785	0.75887	0.72204	0.71685
0.01868	0.98807	0.93616	0.90742	0.91285	0.78277	0.76372	0.72662	0.72158
0.01877	0.98874	0.93783	0.91032	0.91663	0.78753	0.76851	0.73103	0.72547
0.01886	0.98938	0.93952	0.91339	0.92077	0.79193	0.77327	0.73606	0.7294
0.01895	0.98992	0.94135	0.91664	0.9252	0.79642	0.77787	0.74157	0.73368
0.01904	0.98998	0.94303	0.91936	0.929	0.80069	0.78207	0.7465	0.73801
0.01914	0.98992	0.94455	0.92143	0.93245	0.80446	0.78573	0.75061	0.74208
0.01923	0.9902	0.94586	0.92342	0.93616	0.80829	0.78941	0.75457	0.74592
0.01932	0.99048	0.94713	0.92534	0.93987	0.8121	0.79323	0.75839	0.74971
0.01941	0.99055	0.94853	0.92705	0.94301	0.81535	0.79696	0.76215	0.75349
0.0195	0.99119	0.95014	0.92909	0.94614	0.81848	0.80095	0.76626	0.75743
0.0196	0.9922	0.95203	0.93187	0.94951	0.82183	0.80495	0.7703	0.76149
0.01969	0.99296	0.95359	0.93459	0.95269	0.82527	0.80834	0.77321	0.76532
0.01978	0.99352	0.955	0.93692	0.95529	0.82842	0.81095	0.77551	0.7687
0.01987	0.99422	0.95647	0.93918	0.95792	0.83152	0.81369	0.77825	0.77207
0.01996	0.99487	0.95793	0.94113	0.96091	0.83443	0.81694	0.78137	0.77568
0.02006	0.99528	0.95935	0.94258	0.96386	0.83676	0.81998	0.7844	0.77913
0.02015	0.99564	0.96071	0.94386	0.96645	0.83883	0.82254	0.78736	0.78245
0.02024	0.99596	0.96193	0.94507	0.96925	0.84118	0.82482	0.78986	0.78555
0.02033	0.99602	0.96301	0.94612	0.97239	0.84376	0.82702	0.79203	0.78853
0.02042	0.99609	0.96395	0.94694	0.97539	0.84617	0.82934	0.79438	0.7917
0.02052	0.99611	0.96491	0.94753	0.97792	0.84826	0.83199	0.79712	0.79479
0.02061	0.99587	0.96561	0.94789	0.98022	0.84992	0.83475	0.79975	0.79787
0.0207	0.99581	0.96613	0.94813	0.98263	0.85124	0.83723	0.80206	0.80041
0.02079	0.99584	0.96653	0.94851	0.98437	0.85242	0.83907	0.80403	0.80241
0.02088	0.99574	0.9668	0.94904	0.98561	0.85411	0.84054	0.80581	0.80438
0.02098	0.99564	0.96712	0.94967	0.98671	0.85625	0.84223	0.80767	0.80632
0.02107	0.99581	0.96762	0.95065	0.9879	0.8584	0.84419	0.80983	0.80835
0.02116	0.99632	0.96812	0.95202	0.98937	0.86052	0.84614	0.81232	0.81083
0.02125	0.99661	0.96839	0.95322	0.9908	0.86253	0.84806	0.8146	0.81333
0.02134	0.99684	0.96849	0.95429	0.99231	0.86435	0.85002	0.81662	0.81569
0.02144	0.99733	0.96894	0.95545	0.9939	0.86655	0.85204	0.81864	0.81815
0.02153	0.9977	0.96972	0.95657	0.99519	0.86894	0.85396	0.82075	0.82093
0.02162	0.99778	0.97012	0.95728	0.99651	0.87114	0.85605	0.82293	0.82344

0.02171	0.99788	0.97033	0.9582	0.99785	0.873	0.85852	0.82492	0.82554
0.0218	0.99807	0.97071	0.95945	0.99942	0.87465	0.86096	0.82676	0.82752
0.0219	0.99814	0.97125	0.96055	1.00083	0.87601	0.86315	0.82848	0.82952
0.02199	0.99783	0.97174	0.9611	1.00168	0.87709	0.86487	0.82983	0.83134
0.02208	0.9975	0.972	0.96118	1.00254	0.87794	0.86637	0.83115	0.83309
0.02217	0.99739	0.97237	0.96131	1.00388	0.87928	0.86808	0.83296	0.83501
0.02226	0.99734	0.97299	0.96178	1.00549	0.88086	0.86982	0.83495	0.83694
0.02236	0.99731	0.97376	0.9624	1.00699	0.88247	0.87181	0.83679	0.8387
0.02245	0.99743	0.97484	0.96353	1.0084	0.88436	0.8737	0.8388	0.84082
0.02254	0.99776	0.97607	0.96463	1.00995	0.88608	0.87539	0.84095	0.84314
0.02263	0.99825	0.97691	0.96543	1.01164	0.8877	0.87711	0.84294	0.84555
0.02272	0.99862	0.97743	0.96619	1.0131	0.88965	0.87886	0.84468	0.84778
0.02282	0.99888	0.97783	0.9669	1.01419	0.89173	0.88042	0.84624	0.84937
0.02291	0.99902	0.97833	0.96761	1.01539	0.89369	0.88161	0.84764	0.85035
0.023	0.99901	0.97884	0.96805	1.01614	0.89494	0.88239	0.84883	0.85118
0.02309	0.99885	0.9789	0.9681	1.01599	0.89567	0.88325	0.84982	0.85212
0.02318	0.99877	0.97858	0.96827	1.01573	0.89645	0.88402	0.8507	0.85318
0.02328	0.99893	0.97831	0.96851	1.01603	0.89734	0.885	0.85144	0.85426
0.02337	0.99892	0.97801	0.96883	1.01663	0.89851	0.88618	0.85259	0.85549
0.02346	0.99841	0.97757	0.96891	1.01694	0.89961	0.88713	0.85396	0.85626
0.02355	0.99786	0.97734	0.96886	1.01732	0.90041	0.88782	0.85548	0.8568
0.02364	0.99777	0.97746	0.96913	1.01811	0.90122	0.88874	0.85734	0.85794
0.02374	0.99809	0.97781	0.96989	1.01887	0.90229	0.89006	0.85923	0.86015
0.02383	0.99862	0.97824	0.97106	1.0199	0.90392	0.89193	0.86098	0.86279
0.02392	0.99925	0.97879	0.97237	1.02141	0.90591	0.89406	0.8625	0.86491
0.02401	0.99969	0.97924	0.97336	1.02296	0.90746	0.89616	0.8641	0.86656
0.0241	0.99964	0.97936	0.97359	1.02369	0.90843	0.89748	0.8657	0.86784
0.0242	0.99936	0.97942	0.97362	1.02355	0.90919	0.89795	0.86667	0.86883
0.02429	0.99936	0.98001	0.97393	1.02348	0.91014	0.89846	0.8674	0.8703
0.02438	0.99959	0.98065	0.9744	1.0239	0.91116	0.89962	0.86835	0.87204
0.02447	0.99986	0.98103	0.97493	1.02442	0.91224	0.90122	0.8693	0.87354
0.02456	0.99981	0.98092	0.97502	1.02454	0.91325	0.90248	0.87014	0.8743
0.02466	0.99956	0.98038	0.97489	1.0246	0.9137	0.90293	0.87091	0.87454
0.02475	0.99928	0.97981	0.97491	1.02483	0.91397	0.90311	0.87198	0.87489
0.02484	0.99926	0.97972	0.97539	1.02557	0.91477	0.90341	0.87326	0.87562
0.02493	0.99974	0.98017	0.97644	1.02696	0.91617	0.90438	0.87457	0.87665
0.02502	1.00037	0.98062	0.97718	1.02847	0.91756	0.90591	0.8758	0.87776
0.02512	1.00094	0.9808	0.97774	1.02958	0.9186	0.90734	0.87714	0.87876
0.02521	1.00139	0.98105	0.97843	1.03034	0.91951	0.90841	0.87853	0.87998
0.0253	1.00137	0.98136	0.97884	1.03082	0.92017	0.90908	0.87947	0.8811
0.02539	1.00133	0.98198	0.97932	1.03111	0.92067	0.91002	0.88026	0.88204
0.02548	1.00135	0.98282	0.97972	1.03148	0.9215	0.91137	0.88131	0.88308
0.02558	1.00124	0.98333	0.97986	1.03186	0.92244	0.91256	0.88228	0.88401
0.02567	1.00091	0.98348	0.98006	1.03175	0.9233	0.91345	0.88304	0.88496
0.02576	1.00039	0.98327	0.98024	1.03127	0.92362	0.914	0.88361	0.88608
0.02585	0.99994	0.98288	0.98038	1.0307	0.92362	0.91422	0.88428	0.88718
0.02594	0.9994	0.98236	0.98033	1.03036	0.92365	0.9144	0.88511	0.88819
0.02604	0.99897	0.98162	0.97992	1.02997	0.92379	0.91462	0.88576	0.88858

0.02613	0.99891	0.98107	0.97958	1.03001	0.92423	0.91514	0.88672	0.88898
0.02622	0.99892	0.98072	0.97958	1.03068	0.92499	0.91563	0.88791	0.88959
0.02631	0.99892	0.98035	0.97983	1.03128	0.92576	0.91592	0.88864	0.89031
0.0264	0.99889	0.98017	0.98008	1.03144	0.92607	0.91605	0.8889	0.89114
0.0265	0.99869	0.97986	0.97969	1.03155	0.92576	0.91602	0.88891	0.89163
0.02659	0.99847	0.97966	0.97909	1.03159	0.92564	0.91609	0.88917	0.89179
0.02668	0.99836	0.9799	0.97899	1.03205	0.92602	0.91673	0.88991	0.89189
0.02677	0.99823	0.98021	0.97927	1.03267	0.92678	0.91773	0.89059	0.89205
0.02686	0.99795	0.98049	0.97981	1.03317	0.92771	0.91883	0.89108	0.89264
0.02696	0.99757	0.98073	0.98047	1.03341	0.92856	0.9196	0.8916	0.89346
0.02705	0.99722	0.98091	0.98097	1.03355	0.92918	0.92033	0.89235	0.89459
0.02714	0.99734	0.98163	0.98168	1.03392	0.92986	0.92138	0.89356	0.89597
0.02723	0.99779	0.9824	0.9823	1.03464	0.93071	0.92265	0.89485	0.89717
0.02732	0.99833	0.98293	0.98273	1.03532	0.9317	0.92388	0.89583	0.89804
0.02742	0.99866	0.98316	0.98298	1.03588	0.93277	0.9251	0.89676	0.89891
0.02751	0.99856	0.98302	0.98302	1.03618	0.93366	0.92602	0.89777	0.90005
0.0276	0.99872	0.98303	0.98304	1.03644	0.93429	0.92696	0.89873	0.90119
0.02769	0.99921	0.98317	0.98294	1.03692	0.93484	0.9277	0.89961	0.90223
0.02778	0.99967	0.98326	0.98293	1.03736	0.93532	0.92832	0.90035	0.90321
0.02788	1.0001	0.9834	0.98269	1.03752	0.93574	0.92887	0.9008	0.90369
0.02797	1.00015	0.98328	0.98194	1.03741	0.93608	0.9292	0.90109	0.90365
0.02806	1	0.98325	0.98145	1.03754	0.93664	0.92984	0.90184	0.90372
0.02815	0.99992	0.98363	0.98162	1.0382	0.93747	0.931	0.90314	0.90448
0.02824	1.00011	0.98426	0.98236	1.03914	0.93854	0.93227	0.9042	0.90576
0.02834	1.00078	0.98498	0.98339	1.04031	0.94	0.93354	0.90493	0.90748
0.02843	1.00104	0.98538	0.98409	1.04114	0.94121	0.93424	0.90549	0.90906
0.02852	1.00095	0.98562	0.9845	1.04142	0.9421	0.93476	0.90634	0.91019
0.02861	1.00082	0.98572	0.98453	1.04172	0.94284	0.93558	0.90721	0.91102
0.0287	1.00063	0.98579	0.98473	1.0421	0.94384	0.9366	0.90825	0.91216
0.0288	1.00044	0.98595	0.98525	1.04227	0.94487	0.93773	0.90939	0.91359
0.02889	1.0004	0.98602	0.9857	1.04213	0.94561	0.93853	0.91031	0.91505
0.02898	1.00057	0.98612	0.98605	1.04168	0.94637	0.93892	0.91094	0.91616
0.02907	1.00071	0.9861	0.98592	1.04092	0.94684	0.93905	0.91133	0.9168
0.02916	1.00068	0.98607	0.98548	1.03971	0.94714	0.93929	0.91158	0.91708
0.02926	1.00062	0.98586	0.98509	1.03849	0.9477	0.93984	0.91175	0.91696
0.02935	1.0007	0.98555	0.98517	1.03797	0.94843	0.94034	0.91172	0.91693
0.02944	1.00101	0.98541	0.9856	1.03752	0.9489	0.94046	0.9119	0.91719
0.02953	1.0014	0.98545	0.98618	1.03737	0.94919	0.94037	0.91247	0.91773
0.02962	1.00159	0.98553	0.98659	1.03755	0.94967	0.94031	0.91295	0.91809
0.02972	1.00155	0.9856	0.98678	1.03781	0.95003	0.94057	0.91317	0.91823
0.02981	1.00132	0.98539	0.98666	1.03796	0.94982	0.94093	0.91348	0.91822
0.0299	1.00117	0.98508	0.98662	1.03811	0.94961	0.94127	0.91412	0.9182
0.02999	1.00107	0.98469	0.98676	1.03854	0.94949	0.94142	0.91487	0.91811
0.03008	1.00124	0.98473	0.98726	1.03943	0.94952	0.9416	0.91587	0.91855
0.03018	1.00136	0.98506	0.98757	1.04009	0.94973	0.94204	0.91702	0.91936
0.03027	1.00107	0.98517	0.98733	1.04057	0.95023	0.94245	0.91765	0.91983
0.03036	1.00063	0.98489	0.98665	1.0406	0.95067	0.94279	0.91755	0.91989
0.03045	1.00029	0.98418	0.98591	1.04011	0.95072	0.94283	0.91743	0.91981

0.03054	0.99988	0.98338	0.9852	1.03924	0.95085	0.94242	0.91764	0.91958
0.03064	0.99952	0.98292	0.98475	1.03854	0.95159	0.94223	0.91812	0.91971
0.03073	0.99932	0.98276	0.98486	1.03844	0.95251	0.9428	0.91867	0.9203
0.03082	0.99934	0.9829	0.98509	1.03847	0.95309	0.9435	0.91927	0.92099
0.03091	0.99984	0.98332	0.98508	1.03856	0.95355	0.94415	0.92017	0.9219
0.031	1.00047	0.98374	0.9852	1.03915	0.95416	0.94515	0.9212	0.92294
0.0311	1.0013	0.98432	0.98602	1.04008	0.95503	0.94664	0.92247	0.92442
0.03119	1.00224	0.9851	0.98719	1.04111	0.95615	0.94827	0.92401	0.92609
0.03128	1.00299	0.98615	0.98818	1.04247	0.95736	0.94977	0.92536	0.92768
0.03137	1.00378	0.98713	0.989	1.04386	0.95846	0.95097	0.92634	0.92916
0.03146	1.00432	0.98772	0.9896	1.04462	0.95922	0.95182	0.92671	0.93024
0.03156	1.00463	0.98823	0.99007	1.04473	0.95976	0.95226	0.92699	0.93102
0.03165	1.00437	0.98841	0.99027	1.04467	0.9601	0.95258	0.92717	0.93144
0.03174	1.00349	0.98799	0.99014	1.04428	0.96023	0.95255	0.92686	0.9312
0.03183	1.00248	0.98754	0.98965	1.04336	0.96018	0.95198	0.92639	0.93052
0.03192	1.00145	0.98723	0.98897	1.04226	0.95999	0.95136	0.92616	0.92993
0.03202	1.00057	0.98686	0.98827	1.04154	0.95952	0.95107	0.92589	0.92953
0.03211	0.99991	0.98632	0.98776	1.04073	0.95906	0.95091	0.92531	0.92916
0.0322	0.99933	0.98578	0.98765	1.03962	0.95878	0.95101	0.92485	0.92875
0.03229	0.99894	0.98536	0.98774	1.03873	0.95852	0.95125	0.9251	0.92848
0.03238	0.99867	0.98514	0.98771	1.03842	0.95838	0.95137	0.92548	0.9284
0.03248	0.99888	0.98545	0.9877	1.03848	0.95865	0.95164	0.9259	0.92877
0.03257	0.99922	0.98588	0.98768	1.0385	0.95914	0.95222	0.9262	0.9295
0.03266	0.99979	0.9863	0.98797	1.03867	0.95968	0.95311	0.92653	0.93053
0.03275	1.00047	0.98647	0.98826	1.03886	0.96006	0.95383	0.92683	0.93161
0.03284	1.0008	0.98639	0.98827	1.03873	0.96029	0.95406	0.92704	0.93247
0.03294	1.0009	0.9862	0.98807	1.03861	0.96033	0.95435	0.92746	0.93316
0.03303	1.00089	0.98611	0.98777	1.03881	0.96058	0.95489	0.92801	0.93422
0.03312	1.00083	0.98655	0.9875	1.03923	0.96115	0.95542	0.92828	0.93544
0.03321	1.00073	0.98708	0.98717	1.03939	0.96161	0.9559	0.92827	0.93641
0.0333	1.0005	0.98728	0.98709	1.03945	0.96222	0.95646	0.9282	0.93707
0.0334	1.00023	0.98755	0.9874	1.03953	0.96303	0.95714	0.92856	0.93778
0.03349	0.99972	0.98766	0.98762	1.03924	0.96356	0.95744	0.92904	0.9383
0.03358	0.99899	0.98746	0.98767	1.03867	0.96398	0.95741	0.92929	0.9382
0.03367	0.99851	0.98775	0.98806	1.03824	0.96449	0.95759	0.92968	0.93816
0.03376	0.99829	0.98855	0.98896	1.03819	0.96513	0.95798	0.93043	0.9385
0.03386	0.99823	0.98943	0.9898	1.03841	0.96559	0.95845	0.93117	0.93882
0.03395	0.99847	0.98991	0.99055	1.03854	0.96594	0.95929	0.932	0.93925
0.03404	0.9987	0.98998	0.99115	1.03873	0.96628	0.95996	0.93298	0.93964
0.03413	0.99904	0.9898	0.99152	1.03918	0.96625	0.96012	0.93399	0.93983
0.03422	0.99958	0.98964	0.99188	1.0398	0.96596	0.96	0.9352	0.9398
0.03432	1.00007	0.98975	0.99217	1.04046	0.96581	0.96009	0.93634	0.94001
0.03441	1.00059	0.99017	0.99235	1.04103	0.96579	0.96051	0.9372	0.94058
0.0345	1.00082	0.99033	0.99239	1.04106	0.96592	0.96098	0.93772	0.94098
0.03459	1.00078	0.99027	0.9923	1.04049	0.96606	0.96126	0.93785	0.94124
0.03468	1.00089	0.99032	0.99246	1.03989	0.96625	0.96137	0.93795	0.94158
0.03478	1.00082	0.99026	0.9924	1.03955	0.96632	0.96121	0.938	0.94185
0.03487	1.00049	0.99021	0.99207	1.03927	0.96636	0.96139	0.93817	0.94201

0.03496	0.99984	0.99017	0.99163	1.03861	0.96634	0.96188	0.93838	0.94222
0.03505	0.99916	0.99015	0.99127	1.03775	0.96623	0.96248	0.93828	0.94252
0.03514	0.99877	0.99019	0.99126	1.03709	0.96644	0.96321	0.93836	0.94276
0.03524	0.99855	0.99048	0.99186	1.03682	0.96692	0.96414	0.93902	0.94312
0.03533	0.99836	0.99043	0.99243	1.03673	0.96722	0.96464	0.9396	0.94351
0.03542	0.99829	0.99001	0.99282	1.03687	0.96739	0.9649	0.94015	0.94401
0.03551	0.99809	0.98945	0.99281	1.03738	0.96752	0.96519	0.94095	0.9442
0.0356	0.99788	0.98929	0.99276	1.03813	0.96785	0.96529	0.94178	0.94425
0.0357	0.998	0.98946	0.9931	1.03873	0.96852	0.96521	0.94232	0.9447
0.03579	0.9985	0.98971	0.99363	1.039	0.96922	0.96521	0.94249	0.94537
0.03588	0.99888	0.98983	0.99403	1.03895	0.96979	0.9653	0.94252	0.94585
0.03597	0.99884	0.98967	0.99406	1.03878	0.97009	0.96526	0.94247	0.94608
0.03606	0.99864	0.98944	0.99369	1.03852	0.97021	0.96515	0.94217	0.94613
0.03616	0.99872	0.98977	0.99343	1.03849	0.97052	0.96533	0.94226	0.94603
0.03625	0.99892	0.99035	0.99309	1.03838	0.9709	0.96569	0.94264	0.94579
0.03634	0.99882	0.99067	0.99287	1.0379	0.97131	0.96584	0.94263	0.94593
0.03643	0.99862	0.99067	0.99312	1.03732	0.97176	0.96619	0.94256	0.9461
0.03652	0.99859	0.99078	0.99347	1.03678	0.97222	0.96702	0.9428	0.94616
0.03662	0.9987	0.99119	0.9935	1.03649	0.97272	0.96807	0.94335	0.94605
0.03671	0.99893	0.99177	0.99334	1.0365	0.97321	0.96904	0.94387	0.94593
0.0368	0.99929	0.99215	0.99314	1.03637	0.97343	0.96962	0.94392	0.94578
0.03689	0.99956	0.99234	0.99291	1.03617	0.97366	0.96966	0.94399	0.94572
0.03698	0.99963	0.99256	0.99272	1.03622	0.97413	0.96959	0.94431	0.94587
0.03708	0.99983	0.99307	0.9928	1.0367	0.97498	0.96982	0.9448	0.9463
0.03717	1.00021	0.99383	0.99301	1.03742	0.97593	0.97049	0.94549	0.94679
0.03726	1.00064	0.99453	0.99299	1.03792	0.97648	0.97103	0.94598	0.94737

Table 9-4 Atmospheric + pentane, mass fraction profile, free diffusion

Elevation(m)	t=0 s	t=3420 s	t=6780 s	t=14820 s	t=25980 s
2.76E-04	-0.00526	-0.00255	-9.67E-04	-0.01033	-0.00108
3.68E-04	-0.00704	-0.0033	-2.38E-04	-0.01077	-0.00123
4.60E-04	-0.0081	-0.00375	7.52E-04	-0.01042	-0.00131
5.52E-04	-0.00862	-0.00346	0.00169	-0.00977	-9.92E-04
6.44E-04	-0.00881	-0.0034	0.00201	-0.00891	-8.20E-04
7.36E-04	-0.00861	-0.00438	0.00189	-0.0075	-7.48E-04
8.28E-04	-0.00804	-0.00548	0.00173	-0.00571	-8.64E-04
9.20E-04	-0.00743	-0.00578	0.00121	-0.00441	-0.00178
1.01E-03	-0.0074	-0.00556	1.25E-04	-0.00438	-0.00336
1.10E-03	-0.0078	-0.00593	-3.90E-04	-0.005	-0.00469
1.20E-03	-0.0075	-0.00656	-2.64E-04	-0.00512	-0.00522
0.00129	-0.00661	-0.00611	6.07E-06	-0.00467	-0.00468
0.00138	-0.00551	-0.00479	1.85E-04	-0.00486	-0.00419
0.00147	-0.00486	-0.00385	4.66E-04	-0.00614	-0.0042
0.00156	-0.00402	-0.00386	0.00111	-0.00682	-0.00351
0.00166	-0.00309	-0.0045	0.00173	-0.00652	-0.0022
0.00175	-0.00294	-0.00429	9.15E-04	-0.00611	-0.0011
0.00184	-0.00425	-0.00422	-0.00115	-0.00626	-6.91E-04
0.00193	-0.0066	-0.00523	-0.00292	-0.00689	-0.00134
0.00202	-0.0088	-0.0065	-0.00393	-0.00666	-0.00206
0.00212	-0.01005	-0.00718	-0.00436	-0.00519	-0.00204
0.00221	-0.01126	-0.00684	-0.00481	-0.00408	-0.00252
0.0023	-0.01191	-0.00598	-0.00473	-0.00309	-0.00327
0.00239	-0.01158	-0.00534	-0.00405	-0.00199	-0.00339
0.00248	-0.01068	-0.00479	-0.00341	-0.00114	-0.00269
0.00258	-0.00912	-0.00394	-0.00311	-5.61E-04	-0.00153
0.00267	-0.00714	-0.00311	-0.00301	-6.80E-04	-5.88E-04
0.00276	-0.00581	-0.00259	-0.00319	-0.00117	-2.31E-04
0.00285	-0.004	-0.0026	-0.00295	-0.00153	3.67E-04
0.00294	-0.00238	-0.00315	-0.00293	-0.0024	5.49E-04
0.00304	-0.00132	-0.0037	-0.00276	-0.00361	-1.16E-04
0.00313	3.47E-04	-0.00383	-0.00199	-0.00419	-0.00121
0.00322	0.00157	-0.00376	-0.00146	-0.00457	-0.00222
0.00331	4.20E-04	-0.00355	-0.00142	-0.0053	-0.00322
0.0034	-5.95E-04	-0.00326	-7.39E-04	-0.00589	-0.0037
0.0035	-0.00116	-0.00321	-5.76E-05	-0.00619	-0.00408
0.00359	-0.00192	-0.00267	-9.72E-05	-0.00652	-0.00415
0.00368	-0.00254	-0.002	-6.64E-04	-0.00647	-0.0041
0.00377	-0.00329	-0.00193	-0.00169	-0.00687	-0.00443
0.00386	-0.00405	-0.00212	-0.00202	-0.00695	-0.00436
0.00396	-0.00295	-0.00271	-0.00139	-0.00628	-0.00332
0.00405	-0.00165	-0.00349	-0.00134	-0.00602	-0.00258
0.00414	-8.67E-04	-0.00386	-0.00126	-0.00614	-0.00222
0.00423	-2.53E-04	-0.00384	-2.69E-04	-0.00571	-0.0019

0.00432	6.53E-04	-0.00376	7.83E-04	-0.00477	-0.0015
0.00442	8.66E-04	-0.00286	0.00154	-0.00341	-8.34E-04
0.00451	3.97E-04	-0.00171	0.0016	-0.00191	-3.58E-04
0.0046	-9.29E-04	-7.02E-04	8.37E-04	-7.54E-04	-8.84E-05
0.00469	-0.00269	4.15E-04	3.00E-04	-1.05E-04	7.55E-04
0.00478	-0.00494	0.00138	1.75E-04	2.53E-04	0.00173
0.00488	-0.00636	0.00204	8.01E-04	6.83E-04	0.00279
0.00497	-0.00735	0.00253	0.00241	3.38E-04	0.00433
0.00506	-0.00779	0.00287	0.00387	-0.00105	0.00565
0.00515	-0.00747	0.00327	0.0044	-0.00262	0.0063
0.00524	-0.00533	0.00357	0.0049	-0.00306	0.00674
0.00534	-0.0021	0.00386	0.00575	-0.00197	0.00701
0.00543	0.00109	0.00419	0.00604	-8.06E-04	0.00675
0.00552	0.00334	0.00417	0.00525	-5.50E-04	0.00645
0.00561	0.0052	0.00394	0.00347	-4.73E-04	0.00576
0.0057	0.00655	0.0035	0.00195	3.35E-04	0.00508
0.0058	0.00753	0.00285	0.00192	0.00165	0.00476
0.00589	0.00707	0.00231	0.00235	0.00203	0.00425
0.00598	0.00538	0.00192	0.00171	8.28E-04	0.00321
0.00607	0.0039	0.00127	6.70E-04	-3.32E-04	0.00264
0.00616	0.00286	5.80E-04	2.03E-04	-6.10E-04	0.0021
0.00626	0.00188	4.36E-04	6.22E-04	-4.13E-04	0.00172
0.00635	4.28E-04	6.51E-04	0.00148	-3.25E-04	0.00129
0.00644	-0.00178	0.00121	0.00154	-0.00117	7.93E-04
0.00653	-0.00365	0.00181	7.59E-04	-0.00201	4.85E-04
0.00662	-0.0046	0.00194	4.73E-04	-0.00204	5.98E-04
0.00672	-0.00445	0.00209	9.81E-04	-0.00189	8.27E-04
0.00681	-0.00351	0.00224	0.00138	-0.00195	0.00121
0.0069	-0.00222	0.0017	0.00133	-0.00225	0.0012
0.00699	-0.00104	7.04E-04	0.00173	-0.00242	0.00148
0.00708	-5.15E-05	-5.97E-04	0.00321	-0.00221	0.00183
0.00718	1.49E-05	-9.90E-04	0.00524	-0.00111	0.00215
0.00727	1.06E-04	-5.47E-04	0.00743	8.47E-04	0.0029
0.00736	-5.74E-04	-9.62E-05	0.00832	0.00204	0.00323
0.00745	-9.42E-04	5.82E-04	0.00849	0.00251	0.0032
0.00754	-9.53E-05	0.00121	0.00883	0.00317	0.00421
0.00764	0.00179	0.00171	0.00889	0.00426	0.00546
0.00773	0.00405	0.00255	0.00826	0.00516	0.00667
0.00782	0.00692	0.00282	0.00747	0.00508	0.00794
0.00791	0.00818	0.00229	0.00595	0.0041	0.00833
0.008	0.00884	0.00185	0.00514	0.00391	0.00898
0.0081	0.00813	0.00131	0.00461	0.00378	0.00904
0.00819	0.00495	0.00167	0.00342	0.00282	0.00737
0.00828	5.94E-04	0.00171	0.0016	0.00131	0.00473
0.00837	-0.00229	5.44E-04	4.41E-05	2.82E-04	0.00202
0.00846	-0.00492	-0.00172	-0.0012	-3.26E-04	-5.83E-04
0.00856	-0.00659	-0.00363	-0.00177	-7.45E-04	-0.00219
0.00865	-0.00754	-0.00465	-0.00186	-0.00163	-0.00304

0.00874	-0.0073	-0.00516	-0.0014	-0.00219	-0.00261
0.00883	-0.00618	-0.00574	-2.02E-04	-0.00157	-0.00111
0.00892	-0.00353	-0.0055	0.00161	-3.58E-04	9.89E-04
0.00902	-3.03E-05	-0.00421	0.00358	4.77E-04	0.00366
0.00911	0.00437	-0.00201	0.00539	0.0013	0.00626
0.0092	0.00806	2.80E-04	0.00683	0.00199	0.00807
0.00929	0.01037	0.00192	0.0077	0.00302	0.0091
0.00938	0.01094	0.0029	0.00808	0.00419	0.00967
0.00948	0.01112	0.00348	0.00843	0.00496	0.0106
0.00957	0.01042	0.00377	0.00877	0.0056	0.0123
0.00966	0.00823	0.00447	0.00854	0.00635	0.01359
0.00975	0.00552	0.00547	0.00826	0.00681	0.01458
0.00984	0.00429	0.00615	0.00861	0.00737	0.01572
0.00994	0.00353	0.00648	0.00941	0.00752	0.01679
0.01003	0.00365	0.00696	0.01037	0.00779	0.01806
0.01012	0.00473	0.00688	0.01125	0.00869	0.01975
0.01021	0.00644	0.00644	0.01213	0.00998	0.02127
0.0103	0.00873	0.00595	0.01343	0.01131	0.0228
0.0104	0.01106	0.00632	0.0149	0.01191	0.02467
0.01049	0.01226	0.00728	0.01584	0.01156	0.02639
0.01058	0.01463	0.0082	0.01647	0.0118	0.02835
0.01067	0.01829	0.00897	0.01776	0.01287	0.03031
0.01076	0.02144	0.00996	0.01983	0.01416	0.03144
0.01086	0.02339	0.01107	0.02126	0.01427	0.03126
0.01095	0.02358	0.01159	0.022	0.01353	0.03085
0.01104	0.02315	0.01074	0.0227	0.01399	0.03179
0.01113	0.0235	0.00972	0.02333	0.01545	0.03412
0.01122	0.02266	0.01009	0.02377	0.01679	0.0367
0.01132	0.02063	0.01085	0.02365	0.01761	0.03924
0.01141	0.01911	0.01151	0.02248	0.01798	0.04201
0.0115	0.01829	0.01239	0.02154	0.01943	0.04587
0.01159	0.01875	0.01313	0.0215	0.02191	0.05091
0.01168	0.01962	0.01394	0.02237	0.02403	0.05542
0.01178	0.0198	0.01511	0.02462	0.02692	0.05995
0.01187	0.0202	0.01608	0.02766	0.03081	0.06538
0.01196	0.02018	0.01773	0.03035	0.03498	0.07133
0.01205	0.01978	0.02003	0.03308	0.03896	0.07821
0.01214	0.01987	0.02202	0.03648	0.04258	0.08622
0.01224	0.01989	0.02432	0.0399	0.04667	0.09521
0.01233	0.01939	0.02687	0.04277	0.0521	0.10572
0.01242	0.02029	0.02911	0.04517	0.05779	0.11715
0.01251	0.02222	0.03115	0.04782	0.06339	0.12927
0.0126	0.02455	0.03283	0.05114	0.06932	0.14221
0.0127	0.0269	0.03439	0.05483	0.07635	0.15566
0.01279	0.02966	0.03622	0.05875	0.08467	0.16974
0.01288	0.03234	0.03803	0.06338	0.09381	0.18397
0.01297	0.03624	0.04025	0.06818	0.10312	0.19734
0.01306	0.04019	0.04324	0.0727	0.11208	0.21021

0.01316	0.04373	0.04639	0.07726	0.12143	0.22315
0.01325	0.04628	0.04896	0.08236	0.13204	0.23673
0.01334	0.04841	0.05098	0.08862	0.14362	0.25087
0.01343	0.0492	0.05324	0.09546	0.1554	0.26458
0.01352	0.05031	0.05555	0.1026	0.16724	0.27745
0.01362	0.05255	0.05793	0.1113	0.18001	0.29087
0.01371	0.05526	0.06011	0.12205	0.19445	0.30513
0.0138	0.05829	0.0627	0.13435	0.21042	0.31945
0.01389	0.06297	0.06699	0.14824	0.22656	0.33278
0.01398	0.0685	0.07342	0.16334	0.24297	0.34532
0.01408	0.07397	0.08077	0.17979	0.25996	0.35795
0.01417	0.079	0.08868	0.19751	0.27774	0.37108
0.01426	0.08331	0.0968	0.21572	0.29579	0.38453
0.01435	0.08629	0.10601	0.23404	0.31343	0.39757
0.01444	0.08854	0.11649	0.25272	0.33037	0.40967
0.01454	0.0909	0.12743	0.27206	0.34743	0.42139
0.01463	0.09457	0.13882	0.2918	0.36438	0.43295
0.01472	0.1007	0.15213	0.31157	0.38121	0.44448
0.01481	0.10918	0.16833	0.33147	0.3973	0.45568
0.0149	0.11799	0.18778	0.35157	0.4125	0.46592
0.015	0.12877	0.20923	0.37176	0.4276	0.47592
0.01509	0.14134	0.23127	0.39176	0.44293	0.48682
0.01518	0.15534	0.25485	0.41091	0.45791	0.49863
0.01527	0.17066	0.28004	0.42929	0.47223	0.51061
0.01536	0.18798	0.3061	0.44749	0.4861	0.52235
0.01546	0.2077	0.33219	0.46574	0.50016	0.53409
0.01555	0.23219	0.3583	0.48406	0.51426	0.54611
0.01564	0.26125	0.3852	0.50238	0.52844	0.55813
0.01573	0.2948	0.41372	0.52025	0.54258	0.56965
0.01582	0.33274	0.44296	0.5378	0.55665	0.58105
0.01592	0.37471	0.47242	0.55579	0.57098	0.59319
0.01601	0.41875	0.50212	0.57382	0.5855	0.60542
0.0161	0.46386	0.5325	0.59143	0.60022	0.61752
0.01619	0.50854	0.56262	0.60875	0.6153	0.6299
0.01628	0.55184	0.59209	0.62604	0.63083	0.64267
0.01638	0.59377	0.62071	0.6436	0.64646	0.6557
0.01647	0.63346	0.64857	0.66168	0.66236	0.66885
0.01656	0.66954	0.67555	0.68011	0.67854	0.6816
0.01665	0.70287	0.70115	0.69873	0.69467	0.6944
0.01674	0.73398	0.72518	0.71713	0.71057	0.70748
0.01684	0.76254	0.748	0.73518	0.72638	0.72054
0.01693	0.78842	0.76946	0.75269	0.74169	0.73339
0.01702	0.81189	0.78968	0.76999	0.75649	0.74603
0.01711	0.83297	0.80845	0.78675	0.77039	0.75787
0.0172	0.85234	0.826	0.80224	0.78322	0.76905
0.0173	0.86965	0.84219	0.8167	0.79575	0.78019
0.01739	0.88409	0.85701	0.83055	0.808	0.79129
0.01748	0.89618	0.87075	0.84366	0.81952	0.80178

0.01757	0.9072	0.88329	0.8561	0.83044	0.81166
0.01766	0.91681	0.89465	0.86779	0.8406	0.82083
0.01776	0.92486	0.90535	0.87869	0.85034	0.82957
0.01785	0.93202	0.91494	0.88901	0.86002	0.83798
0.01794	0.93915	0.9233	0.89869	0.86916	0.84602
0.01803	0.94627	0.9307	0.90776	0.87766	0.85384
0.01812	0.95359	0.93713	0.91654	0.88555	0.86129
0.01822	0.96002	0.94276	0.92473	0.89263	0.86823
0.01831	0.96569	0.94785	0.93179	0.89913	0.87486
0.0184	0.97076	0.95213	0.93772	0.90518	0.8814
0.01849	0.97486	0.95591	0.9427	0.91082	0.88773
0.01858	0.9777	0.95966	0.94698	0.91625	0.89344
0.01868	0.98039	0.9633	0.95075	0.92132	0.89831
0.01877	0.98245	0.96667	0.95381	0.92585	0.90257
0.01886	0.98407	0.96959	0.95638	0.92994	0.90655
0.01895	0.98579	0.97208	0.95877	0.93378	0.91045
0.01904	0.98766	0.97432	0.96132	0.93742	0.91446
0.01914	0.98934	0.97633	0.96399	0.94071	0.91832
0.01923	0.99153	0.978	0.9666	0.94346	0.92164
0.01932	0.99388	0.9794	0.96895	0.94583	0.92461
0.01941	0.99583	0.98072	0.97086	0.94827	0.92763
0.0195	0.99716	0.98201	0.9722	0.95098	0.9305
0.0196	0.99794	0.98308	0.97359	0.95384	0.93345
0.01969	0.99801	0.98392	0.97481	0.95636	0.9361
0.01978	0.99822	0.98492	0.97588	0.9584	0.9384
0.01987	0.99842	0.986	0.97707	0.96035	0.94093
0.01996	0.99842	0.98687	0.97831	0.96254	0.94377
0.02006	0.99866	0.98767	0.97962	0.96476	0.94644
0.02015	0.99951	0.98862	0.98116	0.96658	0.94883
0.02024	1.00021	0.98962	0.98241	0.96768	0.95077
0.02033	1.00132	0.99066	0.98355	0.96873	0.95256
0.02042	1.00284	0.99136	0.9847	0.97014	0.95444
0.02052	1.00413	0.99189	0.98564	0.97173	0.95621
0.02061	1.00468	0.99262	0.98659	0.97332	0.95784
0.0207	1.00451	0.99342	0.98758	0.97463	0.95961
0.02079	1.00367	0.99417	0.98866	0.97598	0.96162
0.02088	1.00306	0.99492	0.9899	0.97769	0.96371
0.02098	1.00244	0.99556	0.9912	0.97943	0.96584
0.02107	1.00152	0.99626	0.99228	0.98093	0.9679
0.02116	1.00048	0.99712	0.99318	0.98227	0.96967
0.02125	1.00004	0.99779	0.99396	0.98336	0.97137
0.02134	1.00016	0.99823	0.99474	0.98443	0.97299
0.02144	1.00101	0.99853	0.99543	0.98553	0.97449
0.02153	1.00232	0.99854	0.99616	0.98634	0.97569
0.02162	1.00407	0.99843	0.99672	0.98699	0.97652
0.02171	1.00569	0.99839	0.99725	0.98769	0.97742
0.0218	1.00703	0.99834	0.9979	0.98847	0.97849
0.0219	1.00791	0.9984	0.99845	0.98907	0.97922

0.02199	1.00821	0.99845	0.99883	0.98945	0.9797
0.02208	1.00748	0.99845	0.99922	0.98989	0.98041
0.02217	1.00622	0.99852	0.99961	0.99052	0.98141
0.02226	1.00447	0.99871	1.00013	0.99121	0.98252
0.02236	1.00288	0.99896	1.00066	0.99194	0.98328
0.02245	1.00139	0.99906	1.00092	0.99253	0.98384
0.02254	1.00031	0.99891	1.0009	0.9929	0.98439
0.02263	0.9999	0.99854	1.00077	0.99313	0.9849
0.02272	1.00075	0.99821	1.00062	0.99303	0.9852
0.02282	1.00187	0.99812	1.00051	0.99295	0.98535
0.02291	1.0029	0.99787	1.0004	0.99297	0.9855
0.023	1.00404	0.9973	1.0003	0.99283	0.98575
0.02309	1.00526	0.99676	1.00025	0.99245	0.98625
0.02318	1.00576	0.99659	1.00023	0.99239	0.9869
0.02328	1.00577	0.99664	1.00007	0.99248	0.98728
0.02337	1.00539	0.99643	0.99978	0.99253	0.98721
0.02346	1.00484	0.99579	0.99949	0.9925	0.98727
0.02355	1.004	0.99509	0.99901	0.9923	0.98746
0.02364	1.00259	0.99477	0.99846	0.99212	0.98767
0.02374	1.00112	0.99447	0.99791	0.99209	0.9876
0.02383	1.00018	0.99402	0.99756	0.99201	0.98754
0.02392	0.99985	0.99343	0.9976	0.9921	0.98796
0.02401	0.99969	0.99279	0.99778	0.99228	0.98874
0.0241	0.99957	0.99274	0.99785	0.9924	0.98929
0.0242	0.99964	0.99298	0.99787	0.99279	0.98955
0.02429	0.99975	0.99299	0.99796	0.99322	0.98964
0.02438	0.99988	0.99298	0.99829	0.99365	0.98995
0.02447	1.00004	0.99293	0.99867	0.99393	0.99017
0.02456	0.99989	0.99305	0.99874	0.99395	0.99008
0.02466	0.99912	0.99336	0.99858	0.99417	0.99003
0.02475	0.9981	0.99326	0.99838	0.99464	0.99018
0.02484	0.99695	0.99301	0.99821	0.99484	0.99041
0.02493	0.99611	0.99297	0.99797	0.99474	0.99071
0.02502	0.99555	0.99291	0.9977	0.99457	0.99106
0.02512	0.99501	0.99252	0.99744	0.9945	0.99143
0.02521	0.99439	0.99196	0.99747	0.99472	0.992
0.0253	0.99393	0.99149	0.99758	0.99492	0.99242
0.02539	0.99332	0.99135	0.99771	0.9949	0.99273
0.02548	0.99318	0.99124	0.998	0.99505	0.99318
0.02558	0.99362	0.99095	0.99835	0.99538	0.99369
0.02567	0.99436	0.99086	0.99856	0.99581	0.99412
0.02576	0.99526	0.99111	0.99872	0.99628	0.99456
0.02585	0.99641	0.99145	0.99869	0.99659	0.99481
0.02594	0.99733	0.99171	0.99854	0.99684	0.99494
0.02604	0.99803	0.99177	0.99816	0.99694	0.99501
0.02613	0.99843	0.99174	0.99746	0.9968	0.99514
0.02622	0.9984	0.99167	0.99685	0.99686	0.99538
0.02631	0.99795	0.99127	0.99659	0.99703	0.9957

0.0264	0.99777	0.99067	0.99672	0.99732	0.99614
0.0265	0.99767	0.99023	0.99694	0.99764	0.99662
0.02659	0.99764	0.99004	0.9971	0.99775	0.99705