micromixing is better for the orifice jet than for the tube jet under all conditions studied.

The general effect of an increase in average shroud velocity, neglecting particular variations, is an increase in all the mixing distances used and a reduction in the quality of micromixing. The general effect of duct velocity on the mixing parameters is small. The best micromixing is obtained with the highest R_m and lowest R_v.

NOTATION

B = bulk mixing distance
C = orifice velocity coefficient
d = diameter of orifice
D = diameter of main duct
g = gravitational constant
h = head of fluid
K = orifice discharge coefficient
K_m = constant in tube jet macromixing–distance correlation
K_p = constant in penetration–distance correlation
m = area ratio
M = macromixing distance
p = pressure
P = penetration distance
R_m = ratio of mass flow rate of sidestream per unit area of orifice to the mass flow rate of mainstream per unit area of main duct
R_v = ratio of volume flow rate of sidestream per unit area of orifice to the volume flow rate of the mainstream per unit area of main duct
v = volume per unit mass
V_D = average main-duct velocity
V_s = average orifice shroud velocity
$\overline{V}$ = average velocity in orifice discharge coefficient equation = $V_3 + (V_2/2)m$; subscripts 3 and 2 refer to the shroud velocity downstream from the orifice and the orifice velocity respectively
Y = expansion factor
ρ_d = density of sidestream gas
ρ_D = density of mainstream gas

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COMMUNICATIONS TO THE EDITOR

On the Use of the Activity Driving Force in Rate Equations

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It is often stated that the proper driving force for the diffusion equations is chemical activity, rather than concentration. To test this theory one needs both diffusion coefficients and equilibrium data. The recent paper by Rogers, Stannett, and Swarc (*1*) affords both. In Table 1 the columns have the following meaning:

1. Diffusing vapor
2. Concentration, g./g. polymer
3. Activity, p/p_o, calculated from the solubility data given
4. Thermodynamic activity coefficient, $\gamma = a/C$, with $\gamma \rightarrow 1$ as $C \rightarrow C$ (pure)
5. Integral diffusion coefficient,

   $$\overline{D} = 1/C \int_0^C D_o(C)\, dC$$

   D_o being the diffusion coefficient at $C = 0$ and $D_o(C)$ denoting the concentration dependence, which is usually exponential.
6. See 5.
7. As has been suggested by Kuppers and Reid (*2*), the activity coefficients can be predicted by

$$D_o\, d[\gamma'(C)C] = D(C)dC$$

$$\gamma'(C) = \frac{1}{C}\int_0^C \frac{D(C)}{D_o}\, dC = \frac{1}{D_o}\int_0^C \frac{D_o e^{-\delta C}}{C}\, dC = \frac{\overline{D}(C)}{D_o}$$

$\gamma'(C)$ was calculated in this fashion; these however are not the values recorded in Column 7. The γ' calculated from the Kupper-Reid equation is defined differently insofar as $\gamma' \rightarrow 1$ as $C \rightarrow 0$. The correction to a common thermodynamic base was made by obtaining γ^∞ with a linear relationship between log γ and C assumed over the range in question and with $\gamma^1 = \gamma/\gamma^\infty$, where γ is thermodynamic and γ' Kupper-Reid.

8. The γ^∞ used in making the corrections for Column 7.

TABLE 1. ACTIVITY COEFFICIENTS OF VAPORS IN POLYETHYLENE

1	2	3	4	5	6	7	8
Vapor, (0°C.)	$C(10^2)$, g./g. polymer	a	γ(thermodynamic)	$\overline{D}(10^9)$, sq. cm./sec.	$D_o(10^9)$, sq. cm./sec.	γ, predicted from diff. data	γ^∞
Benzene	1.6	0.035	2.2	3.3	1.9	4.25	2.5
	7	0.1	1.4	10.5	1.9	13.80	
Hexane	1.3	0.19	15	2.2	1.2	33	16
	6.8	0.7	10.1	12.7	1.2	169	
Methyl bromide	1.1	0.255	23	12	8.5	33.6	24
	13.2	1.8	14	53	8.5	199	

A comparison of Columns 4 and 7 shows clearly that there is no apparent connection between thermodynamic and kinetic activity coefficients. This conclusion is especially apparent if one examines the variation of activity coefficient with concentration. Equation (7) in the reference by Kuppers and Reid is

$$\gamma' = \frac{e^{\delta C} - 1}{\delta C} \tag{1}$$

In nonpolar systems we know that the (thermodynamic) activity coefficients decrease with increasing concentration, and yet Equation (1) predicts that γ'

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INFORMATION RETRIEVAL

Key Words: Rates-H, Kinetics-H, Mechanics (Not Personnel)-H, Dynamics-H, Physics-H, Particles-I, Fluidizing-I, Calcination-I, Simulation-I, Radioactive Materials-I, Disposal-I, Aluminum Oxide-A, Oxides (Inorganic)-A, Aluminum Nitrate-A, Nitrates (Inorganic)-A, Water-E, Columns (Process)-J, Tracers-J, Radioactive Materials-J, Physical Properties-F, Mechanisms-I, Correlations-I, Growing-I.

Abstract: The kinetics of particle growth in a fluidized calciner have been studied in a three-inch column. The process whereby radioactive waste liquor from nuclear fuel reprocessing can be converted into a disposable granular solid was simulated with aluminum oxide as bed material and aqueous aluminum nitrate as feed. Particle growth was traced through the addition of radioactive seeds. The effects on growth rate of operating variables and physical properties of the feed were investigated. A proposed growth mechanism and a correlation for growth coefficient are included.

Reference: Lee, B. S., Ju Chin Chu, A. A. Jonke, and Stephen Lawroski, **A.I.Ch.E. Journal, 8,** No. 1, p. 53 (March, 1962).

Key Words: Correlations-H, Empirical-, Viscosity-H, Properties (Characteristics)-H, Physical Properties-H, Fluids-I, Gases-I, Liquids-I, Hydrogen-I, Ammonia-I, Water-I, Analysis-J, Dimensional-, Equations-J, Abas-zade.

Abstract: Reported viscosities for gaseous and liquid states of eleven substances are correlated with reduced density using dimensional analysis and the Abas-zade expression for residual viscosity. The critical constants, molecular weight and density of a substance are required to calculate viscosities using the generalized relations which are presented graphically and analytically. Separate realtionships are developed for hydrogen, ammonia and water.

Reference: Jossi, John A., Leonard I. Stiel, and George Thodos, **A.I.Ch.E. Journal, 8,** No. 1, p. 59 (March, 1962).

Key Words: Heat Transfer-I, Transferring-I, Boiling-I, Transport-I, Rates-I, Nucleation-H, Evaporation-H, Condensation-H, Surfaces-H, Bubbles-H, Fluxes-H, Heat-H.

Abstract: A simple one-dimensional transport calculation is made, which indicated that the latent heat transport, by simultaneous evaporation and condensation at different portions of the bubble surfaces, can account for the major portion of the total heat flux in the neighborhood of the departure from subcooled nucleate boiling (burnout). This differs from the previously held view that the stirring action of the bubbles accounted for most of the heat flow in subcooled nucleate boiling. Other evidence is discussed which favors the latent heat transport theory.

Reference: Bankoff, S. G., **A.I.Ch.E. Journal, 8,** No. 1, p. 63 (March, 1962).

Key Words: Solvents-H, Selection-H, Hydrocarbons-I, Paraffins-I, Complexes-I, Polarity-I, Separation-I, Correlations-H, Extraction-I, Distillation-I, Selection-I, Solvents-I.

Abstract: An analysis is given of the role of physical and chemical forces in determining the selectivity of a solvent for different hydrocarbons. Experimental methods are described for determining the chemical forces leading to the formation of acid-base complexes with the hydrocarbons. An equation is proposed for correlating selectivity data in extractive distillation and its applicability is demonstrated with activity coefficent data for saturated and unsaturated hydrocarbons in various polar solvents.

Reference: Anderson, Ralph, Ronald Cambio, and J. M. Prausnitz, **A.I.Ch.E Journal, 8,** No. 1, p. 66 (March, 1962).

Key Words: Mass Transfer-H, Reactions-H, Rates-H, Transport-H, Fluids-I, Diffusion-I, Flow-I, Fluid Flow-I, Laminar Flow-I, Turbulence-I, Concentrations-I, Distribution-, Reactions-F, Coefficients-G, Rates-G, Mass Transfer-G.

Abstract: Studies of mass transfer with rapid, homogeneous, irreversible reactions between dilute species with equal diffusivities have been carried out using a device which reduces the system of mass transfer-reaction equations to the equations for mass transfer in the absence of reaction. The mass transfer relationships for stagnant, laminar, and turbulent reacting systems are developed and calculations are carried out for various cases.

Reference: Toor, H. L., **A.I.Ch.E. Journal, 8,** No. 1, p. 70 (March, 1962).

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(and hence γ also) increases with concentration. Equation (1) then already shows that activity coefficients computed from diffusion data are not likely to agree with those from thermodynamic data. This is also partially borne out by the difficulties experienced by Johnson and Babb (3) in their studies of the concentration dependence of diffusivity in ideal and nonideal binary solutions.

To show the disagreement physically one might argue as follows. In a nonpolar system the partial molar energy of a species i in solution is a maximum (with respect to composition) when i is present in vanishing concentration. That is the energy of a molecule i is higher when it is surrounded by molecules of type j than it is when surrounded by other i molecules. Now energy is highest when the material is an ideal gas, and thus one might say (rather crudely) that molecule i, when surrounded by molecules j, is more gaslike than molecule i when surrounded by other molecules i as indicated in the sketch below.

Energy 0 |——— ideal gas
$\updownarrow$ |——— i surrounded by j
ΔE_i^{∞} |——— i surrounded by i

Hence one would expect the diffusivity of i in j to be largest when i is in an infinitely dilute solution of i in j, since in this state i is less tightly bound. In other words from thermodynamic arguments alone one would expect that in nonpolar systems

$$\frac{d\,D_{i-j}}{d\,c_i} < 0$$

for the dilute region. In fact, however, the experimental diffusion data show that D_{i-j} increases with rising concentration of i. This shows that thermodynamic arguments, while appropriate, are also inadequate for explaining diffusion phenomena.

Thermodynamic properties depend only on the equilibrium or average properties of the molecules. Transport such as diffusion however depends in addition on the extent to which the molecules can fluctuate about these averages. As a result use of thermodynamic activity is not necessarily an improvement over the use of concentration as the driving force for diffusion.

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3. Johnson, P. A., and A. L. Babb, *J. Phys. Chem.*, **60**, 14 (1956).