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Alcohol droplet vaporization in humid air

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Abstract—Experimental and theoretical investigations were conducted for the vaporization of a single alcohol droplet in air with various degrees of humidity. Experimental results show that the vaporization of a volatile alcohol, such as methanol and ethanol, is accompanied by the simultaneous condensation of water vapor on the droplet surface and its subsequent diffusion into the droplet interior such that the associated condensation heat release greatly facilitates the initial gasification rate of alcohol. However, for alcohols which are less volatile, or for liquids which are not miscible with water, atmospheric moisture has practically no effect on the droplet gasification rate. Theoretical results substantiate the above observation.

1. INTRODUCTION

DROPLET vaporization is of relevance to many branches of technological applications. At the fundamental level, gasification of the droplet mass is frequently assumed to be effected through heat transfer from the relatively hot ambience to the relatively cold droplet surface. There is, however, another mechanism, first suggested in ref. [1], through which the thermal as well as latent energy of the environment can be utilized for droplet gasification. That is, in most practical situations the environment is invariably humid to various degrees. Therefore, if the gasifying liquid is highly volatile relative to water, then the water vapor may condense at the droplet surface, releasing the associated heat of condensation which can be directly utilized by the vaporizing liquid for gasification. Because of the large amount of water vapor that can be present in a humid environment, and because of its large heat of condensation, it is reasonable to expect that effects of water vapor condensation on the droplet vaporization rate can be substantial.

The above concept has been experimentally and theoretically substantiated in the present study. The experimental arrangement and results on the vaporization of single droplets in a humid environment will be presented in the next section, which will be followed by the formulation of a theoretical model whose results agree well with the observed phenomena.

2. EXPERIMENTAL INVESTIGATION

2.1. *Experimental specifications*

In the experimental investigation the instantaneous vaporization rate and temperature of a suspended droplet in environments of different moisture contents were determined. The schematic of the apparatus is shown in Fig. 1. The experiment involved recording the magnified image of the vaporizing droplet by a video camera, from which the signal was displayed on a TV monitor, stored on tape for future playback, and digitized and sent to a micro-computer for real-time analysis and printout.

The instantaneous droplet gasification rate was determined by first summing over the heights of the signals from individual scans, from which the surface area of the droplet was computed by assuming it was a body of revolution. This surface area was then equated to that of a sphere, from which the instantaneous, equivalent droplet diameter, $d_s(t)$, was determined. The $d_s^2(t)$ was fitted as a polynomial of degree n, where n was the value for which an increase to a higher degree did not improve the accuracy of fitting. From the fitted $d_s^2(t)$ the instantaneous vaporization rate

$$K(t) = -\mathrm{d}[d_s^2(t)]/\mathrm{d}t$$

was determined. The instantaneous droplet temperature was determined by suspending the droplet at the end of a chromel–constantan thermocouple with a diameter of 0.07 mm while the instantaneous droplet composition was analyzed on a gas chromatograph. Details of the experimental arrangement can be found in refs. [2, 3].

Most of the experiments were conducted with methanol and ethanol. This choice is based on the consideration that since alcohols are miscible with water, the phase-change relation for an alcohol/water mixture is well defined at the droplet interface. Furthermore, because of miscibility the condensed water can also diffuse into the alcohol droplet in accordance with the well-defined diffusion law. On the other hand, if the vaporizing liquid is, say, an alkane which does not mix with water, it is not clear from first principles

NOMENCLATURE

c_p	specific heat
d	droplet diameter
D	mass diffusivity
H	droplet heating rate
$\tilde{H}$	H/L_r
K	vaporization rate constant
K^0	K in dry environment
K_1	$(\lambda_g c_{p,l})/(\lambda_l c_{p,g})$
K_2	λ_g/λ_l
L_i	latent heat of vaporization
$\tilde{L}_i$	L_i/L_r
L_r	a reference latent heat of vaporization
Le	Lewis number, $\lambda/c_p\rho D$
m_i	vaporization rate
$\tilde{m}_i$	$m_i/[4\pi(\lambda_g/c_{p,g})r_s]$
p_i	partial vapor pressure
p_a	ambient pressure
r	radial distance
$\tilde{r}$	r/r_s
t	time
T	temperature
$\tilde{T}$	$c_{p,g}T/L_r$
V_i	partial volume
Y_i	mass fraction.

Greek symbols

α	thermal diffusivity
ε_i	fractional vaporization rate
λ	thermal conductivity
ρ	density
τ	scaled time
ϕ	percent humidity.

Subscripts

0	initial state
F	alcohol
l,g	liquid and gas phases
s,∞	surface and ambience
W	water.

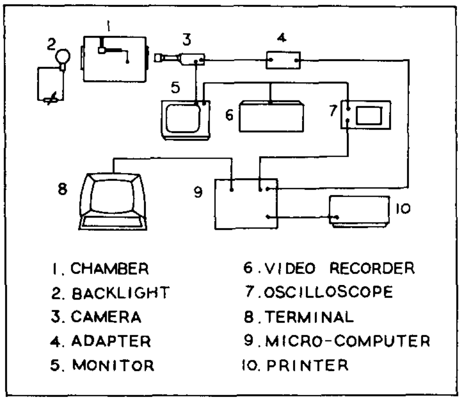

FIG. 1. Schematic of the suspended droplet experimental set-up.

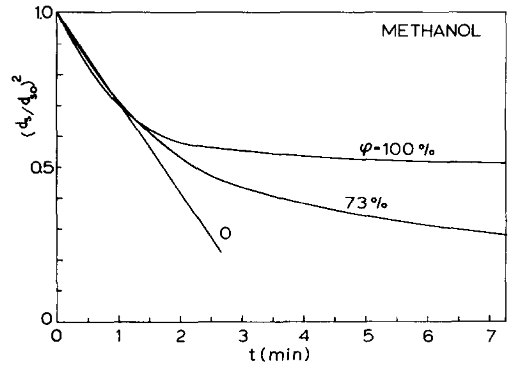

FIG. 2. Demonstration of the deviation of the $(d_s/d_{s0})^2$ vs t curve for vaporization of methanol droplet from linearity in humid air due to water vapor condensation ($d_{s0} = 1.60 \pm 0.02$ mm, $T_\infty = 297$K, $p_a = 745$ mm Hg).

how water vapor condensation is initiated as well as the fate of the condensed water and its interference with subsequent vaporization.

All experiments were conducted in room-temperature air with various degrees of humidity. The initial droplet diameter varied from about 1.0 to 1.8 mm; the exact values are indicated whenever appropriate.

2.2. *Experimental results*

Figure 2 shows the normalized plots of $(d_s/d_{s0})^2$ vs t for a methanol droplet vaporizing in air with $\phi = 0$, 73 and 100% humidity, where ϕ is defined as $\phi = p_W/p_{W,sat}$ ($\times$ 100%) and p_W and $p_{W,sat}$ are, respectively, the partial and saturation pressures of water vapor in the environment of given temperature.

Figure 3 shows the corresponding instantaneous vaporization rate $K(t)$. These results demonstrate clearly that in the absence of humidity the d^2-law is perfectly obeyed, with a constant vaporization rate of 1.22×10^{-2} mm^2 s^{-1}, which we shall designate by K^0. However, in a humid environment K ceases to be a constant. Initially it exceeds the dry limit, but fairly rapidly K becomes less than K^0. For the $\phi = 73\%$ case a constant K is subsequently reached, leading to the eventual complete gasification of the droplet. For the fully humid case we observe the interesting situation of $K \to 0$ at which gasification terminates and a residue (water) droplet of a certain size is permanently left behind.

The above observations are in complete harmony

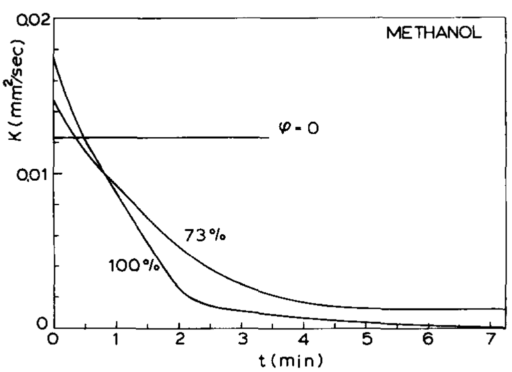

FIG. 3. Development of the instantaneous vaporization rate $K(t)$ of methanol droplet in air with different humidity levels, for the data of Fig. 2.

with physical anticipations. That is, in a humid environment water vapor condensation *initially* greatly enhances the methanol gasification rate. Furthermore, since the present K was measured based on the net rate of change of the droplet size, the gasification rate of methanol is therefore actually higher than the measured K values which also include the rate of water vapor condensation.

However, with continuous condensation the droplet will become more concentrated with water. This leads to a slowing down of water condensation because of the reduction in the water vapor pressure difference between the ambience and the droplet surface. Methanol vaporization is also slowed down because its concentration in the droplet is now highly diluted by water. These cause $K < K^0$. It is also of interest to note that the humid cases have a very long final 'decay' period, during which the rate of methanol gasification is very slow. Indeed, if we were to assess the methanol gasification time based on the period of complete droplet gasification for $\phi < 1$, or the formation of the water residue for $\phi = 1$, then the gasification time in the presence of humidity is greatly lengthened. However, if we take the gasification time to be the period when *most* of the methanol has been gasified, then we can say that the presence of humidity shortens the gasification time. For example, Fig. 2 shows that the extrapolated gasification time in the dry limit is about 3.4 min, while Fig. 3 shows that for the fully humid situation the bulk of the water residue is already formed at about 2 min. Thus, there is a reduction of at least 40% in the gasification time of methanol.

To further substantiate the above interpretation of the droplet vaporization/condensation dynamics, we have also determined the temporal variation of the droplet composition and temperature. Figure 4 shows the variations of the volume fraction of water, defined as the ratio of the volume of water (V_W) to the volume of the water/alcohol mixture (V), and the non-dimensional absolute amount of water, defined as the ratio of V_W to the initial droplet volume (V_0). The results clearly show that (V_W/V) and (V_W/V_0) initially increase until the droplet composition is completely converted to water. Afterward (V_W/V_0) decreases as water starts to vaporize.

Figure 5 shows the measured droplet center temperature for methanol droplets in air with various degrees of humidity. Recognizing that for the present situations the droplet surface regression rate ($\sim 10^{-2}$ mm^2 s^{-1}) is much slower than the liquid-phase thermal diffusivity (~ 1 mm^2 s^{-1}), it is reasonable to assume that the droplet temperature is perpetually maintained uniform such that the measured temperature represents the droplet temperature T_s. It should also be noted that $t = 0$ in the T_s plots represents the instant at which the droplet is suspended

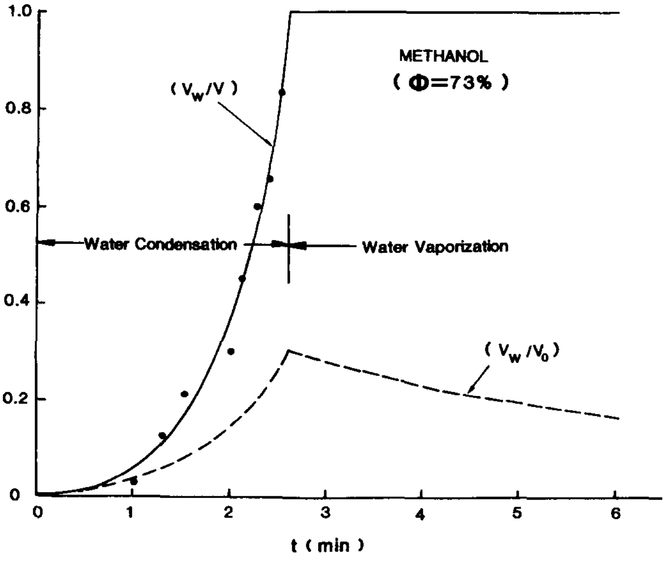

FIG. 4. Development of the instantaneous water concentration in a methanol droplet vaporizing in humid air at 73% humidity ($T_\infty = 297$K).

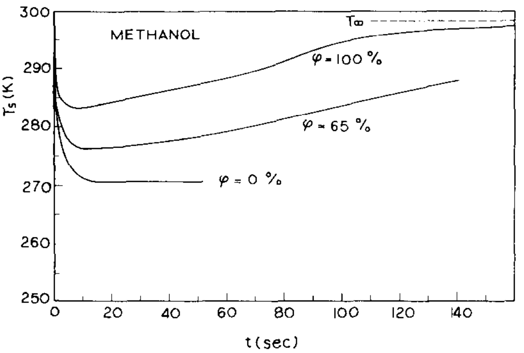

FIG. 5. Development of the droplet temperature for methanol droplets vaporizing in humid air ($T_\infty = 298$K).

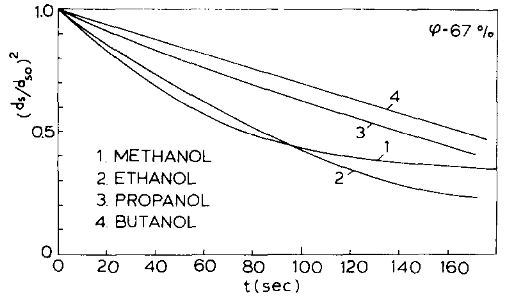

FIG. 6. The $(d_s/d_{s0})^2$ vs t curves for vaporization of methanol, ethanol, propanol, and butanol droplets in humid air ($d_{s0} = 1.08 \pm 0.02$ mm, $T_\infty = 297$K).

but is still vibrating/oscillating due to the disturbances generated during suspension, while $t = 0$ in the $(d_s/d_{s0})^2$ and K plots corresponds to the instant at which such disturbances have damped down. Thus, for the latter plots, effects due to the initial transient are not represented.

It is seen from the T_s plots that for all cases there exists an initial period during which the droplet temperature rapidly decreases from its initial value which is relatively high compared with its instantaneous wet-bulb temperature. In the dry air case the decrease is monotonic and soon the droplet attains a constant temperature. However, in humid air T_s decreases to a minimum and then increases again. This increase is caused by the condensation heat release as well as the gradual enrichment of the droplet composition with water, which has higher wet-bulb temperatures than methanol. It is of interest to note that for the fully-humid case T_s approaches the ambient temperature, T_∞, as the droplet composition gradually becomes more concentrated with water and vaporization slows down.

Experiments have also been conducted for other liquids. Figure 6 shows the droplet size history of methanol, ethanol, propanol, and butanol in 67% humid air. It is seen that as the volatility of the alcohol reduces, effects of humidity on the vaporization rate are also reduced. In particular, for butanol the d^2-law is seen to hold quite well.

Figure 7 shows the size history of hexane droplets in dry and humid air. It is seen that although hexane has the same volatility range as methanol, the presence of moisture has practically no effect on the droplet vaporization rate. Noting that hexane is immiscible with water, it is then clear that condensation of water vapor cannot be easily initiated on the surface of an immiscible liquid. This conjecture is further substantiated by the failure to observe any water micro-droplets on the hexane droplet.

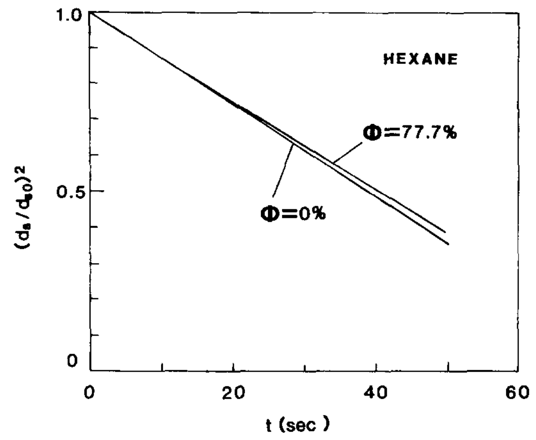

FIG. 7. The droplet size history of a hexane droplet vaporizing in humid air, demonstrating the lack of condensation due to immiscibility ($d_{s0} = 1.56$ mm, $T_\infty = 294$K).

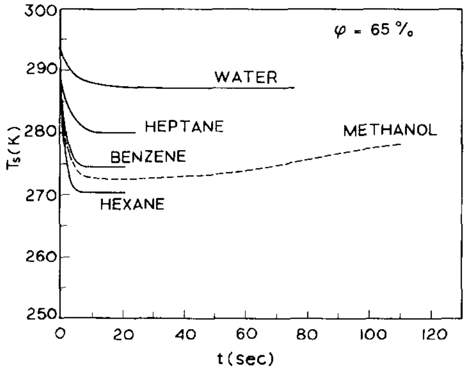

FIG. 8. Development of the droplet temperature for a variety of liquids ($T_\infty = 295$K).

Figure 8 shows the droplet temperature history for a variety of liquids. The qualitatively different behavior of T_s in the presence of water vapor condensation, for the case of methanol, is again demonstrated.

Finally, because of the practical importance of ethanol as a viable alternate fuel, we show in Fig. 9 the variations of its vaporization constant for various degrees of humidity.

3. THEORETICAL MODEL

3.1. *Statement of model and assumptions*

The physical statement of the problem is the following. At time $t = 0$, a droplet of initial radius r_{s0}, temperature T_{s0}, fuel concentration $Y_{F,l,0}$, and water concentration $Y_{W,l,0}$ is allowed to undergo vapor-

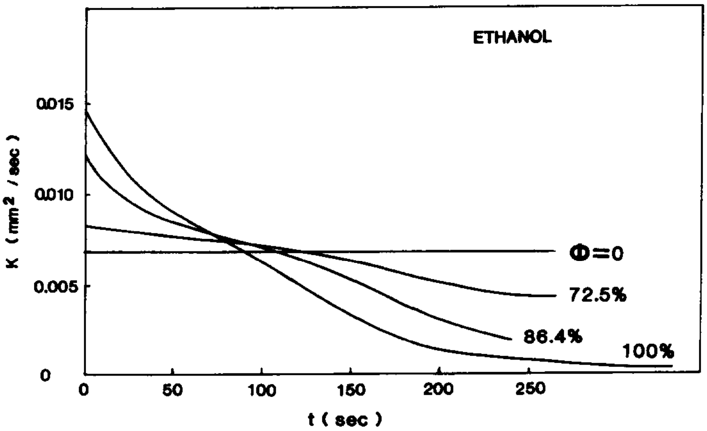

FIG. 9. Development of the instantaneous vaporization rate $K(t)$ of ethanol droplet in air with different humidity levels, for the same experimental conditions as those of Fig. 3.

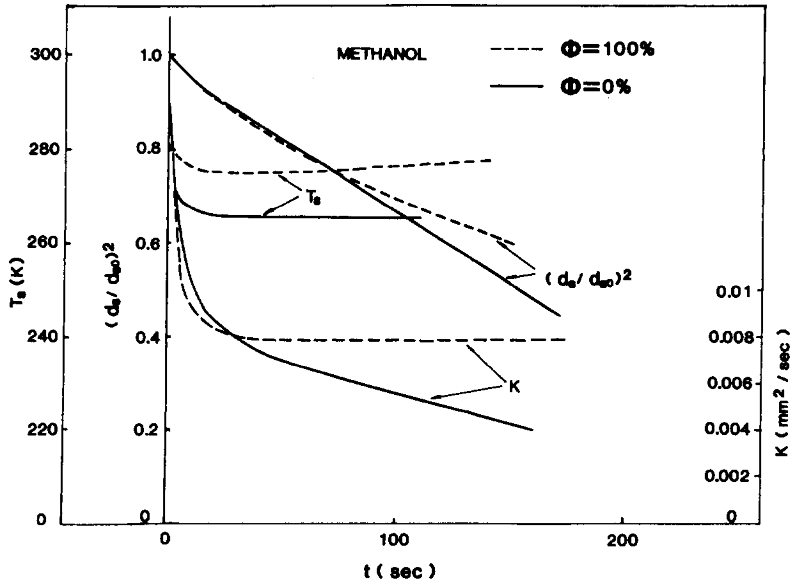

FIG. 10. Calculated temporal variations of $(d_s/d_{s0})^2$, K, and T_s for methanol droplet vaporizing in dry and saturated air respectively ($T_\infty = T_{l,0} = 296$K).

ization in an environment characterized by its temperature T_∞, fuel vapor concentration $Y_{F,\infty}$, and water vapor concentration $Y_{W,\infty}$. Depending on the relative values of $Y_{F,l,0}$, $Y_{F,\infty}$, $T_{W,l,0}$, and $Y_{W,\infty}$, initial vaporization or condensation of either fuel or water is possible. For the sake of discussion we shall assume that initially fuel vaporizes while water condenses. The condensed water will further diffuse into the droplet interior because it is assumed to be miscible with the fuel; this miscibility assumption basically also implies that the fuels of interest here are alcohols because other practical fuels do not mix with water. We are interested in determining the subsequent history of the alcohol vaporization rate, the water condensation rate, the droplet size and temperature, and the amounts of alcohol and water in the droplet.

The present formulation adopts the general multicomponent droplet vaporization and combustion model of refs. [4, 5], which basically assumes quasi-steady gas-phase convective–diffusive transport and liquid-phase transient–diffusive transport; its qualitative validity has been experimentally verified [6, 7]. The only modification of this model in the present formulation is the inclusion of the fuel vapor accumulation effect discussed in ref. [8]. This effect identifies a finite radial location r_∞ at which the influence of the ambience is being felt by the droplet; r_∞ is determined by conserving the amount of vaporized liquid with the amount dispersed in the gas. Thus, using the nomenclature of ref. [5], we find the following solutions for the gas-phase processes and the governing equations for the liquid-phase processes [3].

3.2. *Gas-phase solutions*

The gas-phase temperature and concentration distributions are respectively given by

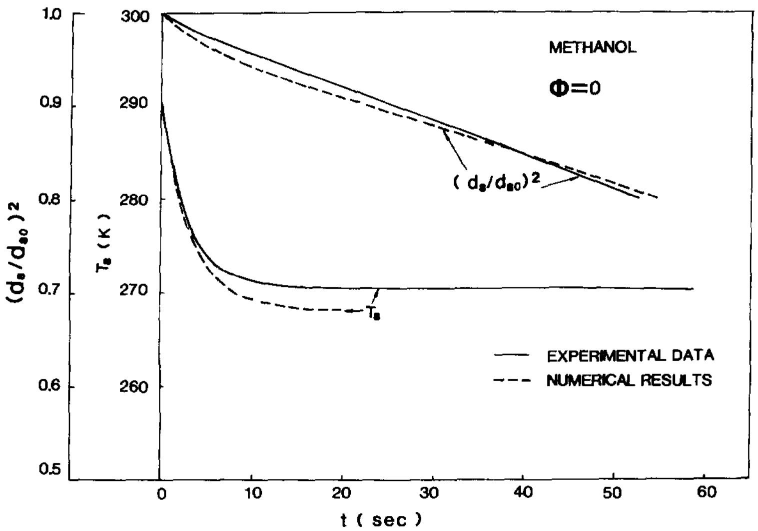

FIG. 11. Comparison between the calculated and measured results for methanol droplet vaporizing in dry air ($T_\infty = T_{l,0} = 298$K, $d_{s0} = 1.60$ mm).

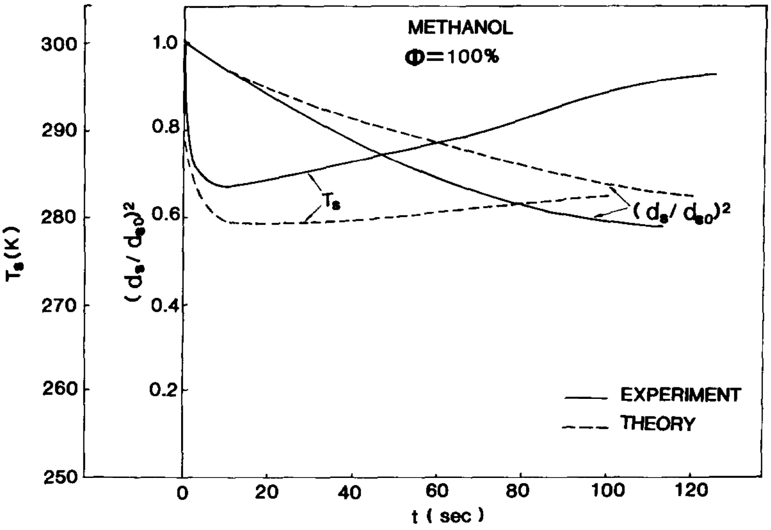

FIG. 12. Comparison between the calculated and measured results for methanol droplet vaporizing in saturated air ($T_\infty = T_{l,0} = 298$K, $d_{s0} = 1.60$ mm).

$$\tilde{T}_g(\tilde{r}) = \tilde{T}_s + (\Sigma\varepsilon_i\tilde{L}_i + \tilde{H})\{\exp[\tilde{m}(1-1/\tilde{r})]-1\} \quad (1)$$

$$Y_{i,g}(\tilde{r}) = \varepsilon_i + (Y_{i,g,s} - \varepsilon_i)\exp[\tilde{m}(1-1/\tilde{r})] \quad (2)$$

while the total vaporization rate $\tilde{m} = \tilde{m}_F + \tilde{m}_W$ is

$$\begin{aligned}\tilde{m} &= \frac{1}{(1-1/\tilde{r}_\infty)}\ln(1+B_H)\\ &= \frac{1}{(1-1/\tilde{r}_\infty)}\ln(1+B_M)\end{aligned} \quad (3)$$

the heat and mass transfer numbers are

$$B_H = \frac{(\tilde{T}_\infty - \tilde{T}_s)}{(\tilde{H} + \Sigma\varepsilon_i\tilde{L}_i)}, \quad B_M = \frac{(Y_{i,g,\infty} - Y_{i,g,s})}{(Y_{i,g,s} - \varepsilon_i)} \quad (4)$$

the fractional mass flux $\varepsilon_i = \tilde{m}_i/\tilde{m}$ is

$$\varepsilon_i = \frac{(Y_{W,g,\infty} - Y_{W,g,s})Y_{F,g,s} + (Y_{F,g,\infty} - Y_{F,g,s})(1 - Y_{W,g,s})}{(Y_{W,g,\infty} - Y_{W,g,s}) + (Y_{F,g,\infty} - Y_{F,g,s})} \quad (5)$$

the amount of heat needed for droplet heating is

$$\tilde{H} = \frac{(\tilde{T}_\infty - \tilde{T}_s)}{B_M} - \Sigma\varepsilon_i\tilde{L}_i \quad (6)$$

and the outer boundary $\tilde{r}_\infty$ for the gas-phase processes are constrained through mass conservation as

$$-\frac{d}{d\tau}\int_0^1 \rho_l\tilde{r}^2\,d\tilde{r} = \frac{d}{d\tau}\int_1^{\tilde{r}_\infty} \rho_g\tilde{r}^2\,d\tilde{r}$$

which yields

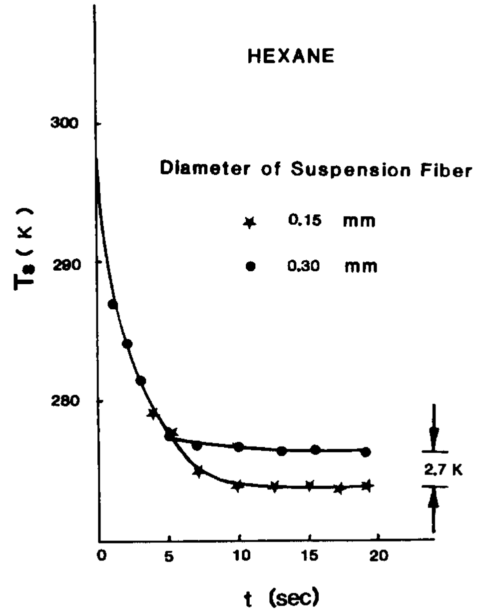

FIG. 13. Demonstration of the effect of heat transfer through the suspension fiber on the droplet temperature ($T_\infty = 298$K).

$$\tilde{r}_\infty(\tau) = \left[1 + \frac{3D_g}{\alpha_l}\int_0^\tau \tilde{m}\,d\tau\right]^{1/3} \tag{7}$$

where

$$\tau = \int_0^t \left[\frac{\alpha_l}{r_s^2(t')}\right] dt' \tag{8}$$

is the scaled time. In the above, $\tilde{m}_i = m_i/[4\pi(\lambda_g/c_{p,g})r_s]$, $\tilde{T} = c_{p,g}T/L_r$, $\tilde{r} = r/r_s(t)$, m_i is the instantaneous vaporization/condensation rate of the ith species, L_i its latent heat of vaporization, and L_r is a reference latent heat which can be taken to be that of water for convenience. These gas-phase solutions are expressed in terms of the surface conditions $\tilde{T}_s$, $\tilde{Y}_{i,g,s}$, and $\tilde{H}$, which are given by the following liquid-phase solutions and the phase-change relations.

3.3. *Liquid-phase equations*

The liquid-phase temperature and species distributions are respectively governed by

$$\frac{d\tilde{T}_l}{d\tau} = \frac{1}{\tilde{r}^2}\left[\frac{\partial}{\partial\tilde{r}}\left(\tilde{r}^2\frac{\partial\tilde{T}_l}{\partial\tilde{r}}\right)\right] - K_1\tilde{m}\tilde{r}\left[\frac{\partial\tilde{T}_l}{\partial\tilde{r}}\right] \tag{9}$$

$$\frac{\partial Y_{i,l}}{\partial\tau} = \frac{1}{Le_l\tilde{r}^2}\left[\frac{\partial}{\partial\tilde{r}}\left(\tilde{r}^2\frac{\partial Y_{i,l}}{\partial\tilde{r}}\right)\right] - K_1\tilde{m}\tilde{r}\left[\frac{\partial Y_{i,l}}{\partial\tilde{r}}\right] \tag{10}$$

subject to the following initial and boundary conditions

$$\tilde{T}_l(\tilde{r},0) = \tilde{T}_{l,0}(\tilde{r}), \quad Y_{i,l}(\tilde{r},0) = Y_{i,l,0}(\tilde{r}) \tag{11}$$

$$\left[\frac{\partial\tilde{T}_l}{\partial\tilde{r}}\right]_{\tilde{r}=0} = 0, \quad \left[\frac{\partial Y_{i,l}}{\partial\tilde{r}}\right]_{\tilde{r}=0} = 0 \tag{12}$$

$$\left[\frac{\partial\tilde{T}_l}{\partial\tilde{r}}\right]_{\tilde{r}=1} = K_2\tilde{m}\tilde{H},$$

$$\left[\frac{\partial Y_{i,l}}{\partial\tilde{r}}\right]_{\tilde{r}=1} = Le_l K_1\tilde{m}(Y_{i,l,s} - \varepsilon_i) \tag{13}$$

where Le_l is the liquid-phase Lewis number which assumes values much greater than unity. The instantaneous droplet size is given by

$$\frac{dr_s^2}{dt} = -\left[\frac{2\lambda_g}{c_{p,g}\rho_l}\right]\tilde{m}. \tag{14}$$

3.4. *Phase-change relation*

Since the phase-change process occurs at a rate much faster than the gas-phase transport processes, the vapor concentration at the droplet surface can be considered to be saturated. An accurate, semi-empirical relation for a binary mixture consisting of components i and j is given in ref. [9] as

$$X_{i,g,s} = \gamma_i X_{i,l,s}(p_i/p_a) \tag{15}$$

where p_a is the ambient pressure, p_i the vapor pressure of i given by

$$\log(p_i) = A_i - \frac{B_i}{T_s - 273.15 + C_i} \tag{16}$$

and the factors γ_i are

$$\gamma_i = \frac{1}{(X_{i,l,s} + A_{ij}X_{j,l,s})}$$
$$\times \exp\left[X_{j,l,s}\left(\frac{A_{ij}}{X_{i,l,s} + A_{ij}X_{j,l,s}} - \frac{A_{ji}}{X_{j,l,s} + A_{ji}X_{i,l,s}}\right)\right] \tag{17}$$

where the coefficients A_i, B_i, C_i, A_{ij} and A_{ji} are given in ref. [9].

Equations (9) and (10) have been solved numerically, using the Crank–Nicolson scheme.

3.5. *Calculated results and comparisons*

Figure 10 shows the calculated results of $(d_s/d_{s0})^2$, K, and T_s vs t for methanol droplet vaporizing in dry and fully saturated air. It is seen that in dry air, after the initial transient period, $(d_s/d_{s0})^2$ vs t is a straight line; and K and T_s are constants, in agreement with the d^2-law. In saturated air, however, the slope of $(d_s/d_{s0})^2$, $K(t)$ and T_s vs t vary due to water vapor condensation on the droplet. Initially, the vaporization rate K exceeds the value in dry air because of condensation heat release on droplet surface. Subsequently, K decreases continuously due to water dilution of the droplet.

Figures 11 and 12 compare the calculated results and experimental data for methanol droplet vaporizing in dry and saturated air. There is general agreement for both $(d_s/d_{s0})^2$ and T_s. Quantitatively the calculated T_s is lower than the experimental data, which leads to slower values of the calculated vaporization rate.

There are several plausible explanations for the observed differences. The first is variable transport effects, which are usually needed for satisfactory quantitative agreement for heat and mass transfer problems of the present nature. Another cause is the heat transfer from the suspension needle or thermocouple. Figure 13 compares the T_s measured with thermocouples of different thicknesses, and shows that the thicker thermocouple (0.3 mm) registers a temperature of 2.7K higher than that recorded by the thinner thermocouple of 0.15 mm.

4. CONCLUDING REMARKS

In the present investigation we have demonstrated that the vaporization of methanol and ethanol droplets in humid air is accompanied by the simultaneous condensation of water vapor at the droplet surface. The significant condensation heat release can greatly enhance the initial alcohol vaporization rate. However, as the droplet becomes more concentrated with water, the droplet vaporization rate decreases. Therefore, while the bulk of alcohol is vaporized relatively fast with increasing humidity, the total droplet lifetime is prolonged.

Our results also show that moisture condensation basically does not occur for alcohols heavier than ethanol, and for liquids which are immiscible with water.

The practical implications of the present results are interesting. That is, methanol and ethanol hold potential as viable alternate fuels. However, concern has been expressed over their relatively higher latent heats of vaporization as compared with the conventional hydrocarbon fuels. This can pose potential difficulty in effecting rapid gasification, mixing, and ignition. Thus, with the additional heat release due to water condensation, the alcohol vaporization rate can be enhanced. Furthermore, the condensed water formed in the alcohol vaporization region/period will be vaporized later, possibly during active combustion. This second stage water vaporization will lower the flame temperature and consequently the amount of such temperature-sensitive pollutants as NO_x.

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VAPORISATION D'UNE GOUTTELETTE D'ALCOOL DANS L'AIR HUMIDE

Résumé—Une recherche expérimentale et théorique est conduite sur la vaporisation d'une gouttelette unique d'alcool dans l'air avec différents degrés d'humidité. Les résultats expérimentaux montrent que la vaporisation d'un alcool volatil tel que le méthanol ou l'éthanol est accompagnée d'une condensation simultanée de vapeur d'eau sur la surface de la goutte, de la diffusion d'eau dans l'intérieur et l'apport de chaleur par condensation facilite la gazéification initiale de l'alcool. Pour les alcools moins volatils ou pour les liquides non miscibles avec l'eau, l'humidité de l'air n'a pratiquement pas d'effet sur la vitesse d'évaporation. Des résultats théoriques appuient ces observations.

DIE VERDUNSTUNG EINES ALKOHOLTROPFENS IN FEUCHTER LUFT

Zusammenfassung—Experimentelle und theoretische Untersuchungen zur Verdunstung eines einzelnen Alkoholtropfens in Luft von unterschiedlicher Feuchte wurden durchgeführt. Die experimentellen Ergebnisse zeigen, daß die Verdunstung eines leicht flüchtigen Alkohols, wie Methanol oder Ethanol, durch die gleichzeitige Kondensation von Wasserdampf an der Oberfläche und der anschließenden Diffusion in das Tropfeninnere begleitet wird, so daß die dadurch freiwerdende Kondensationswärme die anfängliche Verdunstungsrate des Alkohols stark erhöht. Bei weniger flüchtigen Alkoholen oder bei Flüssigkeiten, die mit Wasser nicht mischbar sind, hat die Umgebungsfeuchte praktisch keinen Einfluß auf die Verdunstungsrate der Tropfen. Theoretische Ergegnisse bestätigen die oben genannten Beobachtungen.

ИСПАРЕНИЕ КАПЛИ СПИРТА ВО ВЛАЖНОМ ВОЗДУХЕ

Аннотация—Экспериментально и теоретически исследуется испарение одиночной капли спирта в воздухе с различной влажностью. Опыты показывают, что испарение летучего спирта, такого как метанол и этанол, сопровождается одновременной конденсацией водяного пара на поверхности капли с последующей диффузией внутрь капли, так что связанное с конденсацией выделение тепла значительно увеличивает начальную интенсивность испарения спирта. Однако для менее летучих спиртов или для несмешивающихся с водой жидкостей атмосферная влажность практически не оказывает влияния на интенсивность испарения капли. Теоретические результаты подтверждают эти наблюдения.