Light scattering measurements have been carried out on aqueous solutions of dimethyloleylamine oxide in water, 10^{-6} or 10^{-3} M HCl, in the absence or presence of NaCl to different concentrations up to 5 x 10^{-2} M. Large rodlike micelles are formed in all solutions.

In the presence of NaCl less than 10^{-3} M, light scattering is subject to strong external interference, giving anomalous angular dependence. Separation of the external effect from the internal interference yields radial distribution function of micelles, showing that rodlike micelles exist in solution nonrandomly or in clustering states.

In the presence of more concentrated NaCl, angular dependence of light scattering is normal, indicating no external interference, and shows formation of large, flexible rodlike micelles. The electrostatic effect of protonation in 10^{-3} M HCl is not necessarily manifest, as the micelle size is compared with that in water. With increasing NaCl concentration, larger micelles are formed. In 10^{-3} M HCl in the presence of 10^{-2} M NaCl, the micelle formed has molecular weight of 18 million, and radius of gyration of 2,100 A.

It is concluded that hydration of amine oxide prevents a rodlike micelle from further associating together, but the addition of NaCl dehydrates the amine oxide and increases the micelle size. Dehydration of amine oxide also induces hydrogen bonding between amine oxide and N-hydroxyammonium ion in a micelle.

INTRODUCTION

Dimethyloleylamine oxide, CH_{3}(CH_{2})_{7}CH=CH(CH_{2})_{8}N(CH_{3})_{2}O, is highly soluble in water and aqueous salt solutions, in spite of its having a long hydrocarbon chain and a nonionic head group. We may expect from the micelle size observed for lower alkyl homologs that it can form large rodlike micelles above the low critical micelle concentration.

Amine oxide is a weak base, and it can be protonated at low pH to form N-hydroxyammonium ion.
\( R-N(\text{CH}_3)_20H^+ + R-N(\text{CH}_3)_2O + H^+ \quad R = \text{alkyl or oleyl} \)

Dimethyloleylamine oxide has a pK value of 3.7 to 4.3 in the micellar form, depending on the NaCl concentration. Accordingly, it forms non-ionic micelles in water or at alkaline pH; while it forms cationic micelles in aqueous HCl solutions at pH lower than 2. At intermediate pH, it is present as the cationic-nonionic micelles.

In this work we present our results of light scattering measurements on aqueous solutions of dimethyloleylamine oxide in water and \(10^{-4}\) N or \(10^{-3}\) N HCl, in the absence or presence of NaCl up to \(5 \times 10^{-3}\) M. In \(10^{-4}\) n HCl dimethyloleylamine oxide is half-protonated, thus forming a micelle consisting of an equal composition of amine oxide molecules and N-hydroxyammonium ions. At lower pH our light scattering cells could not be used because of the low stability of their bottom corners against acids where some adhesive material was present.

Since we have encountered complicated situations concerning angular dependence of light scattering, we first give a brief account of light scattering behavior of the dilute micellar solutions. It will make the interpretation of our results more comprehensible. Then we will derive the micelle size and shape as well as the intermicellar interaction. It can be shown that large rodlike micelles are formed and their size and mutual interaction are strongly dependent on the hydration state of the amine oxide group.

**LIGHT SCATTERING IN DILUTE SOLUTIONS**

In light scattering from a dilute solution having surfactant concentration, \(c\) (g cm\(^{-3}\)), the reduced intensity of scattered light is given by

\[
R_g = R_0 + K M_w (c - c_o) P(\theta) S(\theta)
\]

where \(M_w\) is the weight-average molecular weight of micelles, and \(P(\theta)\) and \(S(\theta)\) are the particle scattering factor and the structure factor, respectively, which represent the effects of internal and external interference, respectively. The optical constant is expressed by

\[
K = 2 \pi^2 \lambda^2 \left( \frac{\text{dn}}{\text{dc}} \right)^2 C_1 C_2 / N_A^2 \frac{\lambda}{r_0}^4
\]

where \(N_A\) is Avogadro’s number, \(n\) is the refractive index of the solution for the light of wavelength, \(\lambda\), and \(C_1\) and \(C_2\) are the molar concentrations of HCl and NaCl. The subscript or superindex, \(o\), refers to the solution of the critical micelle concentration, \(c_o\). The critical micelle concentration is very low for dimethyloleylamine oxide and dodecylmethyl-N-hydroxyammonium chloride.

The particle scattering factor, \(P(\theta)\), is given by

\[
P(\theta) = \sum \sum \frac{\sin \mu_{ij}}{\mu^2_{ij}}
\]

where \(i\) and \(j\) stand for two scattering points by distance \(r_{ij}\) apart within a micelle, and \(\mu\) is the magnitude of wave vector of scattered light:

\[
\mu = \left(4\pi n o / \lambda \right) \sin (\theta/2)
\]

The summation extends over all pairs of scattering points within a micelle.

The structure factor, \(S(\theta)\), is given by

\[
S(\theta) = 1 + \frac{1}{4} P(\theta) / \left( R_0 - R_0^0 \right)
\]

where \(r\) is the reciprocal envelope of \(g(\tau)\) is the radial distribution function of micelles.

Light scattering in the reciprocal envelope shows angular dependences, so that it is 

\[
P(\theta) = \left( R_0 - R_0^0 \right) S(\theta) / \left( c - c_o \right)
\]

Equation (1) and equation (5) depends on the remaining cases of angular concentration.

(a) If the experimental solutions are very thin, \(c - c_o\) can be written as a normal form, if \(P(\theta)\), and \(S(\theta)\) are combined, then we have

\[
P(\theta) = \left( R_0 - R_0^0 \right) S(\theta) / \left( c - c_o \right)
\]

(b) If the intermicellar interaction is strong, \(P(\theta)\), and \(S(\theta)\) can be written as a normal form, if \(P(\theta)\), and \(S(\theta)\) are combined, then we have

\[
P(\theta) = \left( R_0 - R_0^0 \right) S(\theta) / \left( c - c_o \right)
\]

Usually, if \(c - c_o\) is small, then

\[
P(\theta) = \left( R_0 - R_0^0 \right) S(\theta) / \left( c - c_o \right)
\]

RODLIKE MICELLES

Since the light scattering behavior is normal for rods and comparable correlation occurs, as long as 20 million, as will be shown later.

In the present work, we have measured the light scattering behavior of dilute micellar solutions at critical micelle concentrations. The critical micelle concentration is very low for dimethyloleylamine oxide and dodecylmethyl-N-hydroxyammonium chloride.
oleyl

in the micellar fluid, it forms non-

mionic cationic surfactants. At intermediate surfactant concentrations, measurements were made of scattering behavior in 10^{-3} N or 10^{-2} M NaCl solutions, with 10^{-3} M NaCl forming a micelle at intermediate concentrations. The micelles and N-hydroxyethyl-N-dodecylde-}

methylamine oxide could not be separated against acids concerning angular dependence of light scattering. It will make the calculation of the angular and concentration dependencies of the reciprocal envelope at a given concentration, as shown in Figure 1, easier. The effect of the solution on the scattering behavior is given by

\[ S(0) = 1 + 4\pi N A (c - c_0) \int_0^\infty \frac{g(r) - 1}{r^2} dr \sin \mu r \mu r \]

where \( r \) is the distance between centers of gravity of two micelles, and \( g(r) \) is the radial distribution function of micelles.

Light scattering results are generally expressed in the form of reciprocal envelope, in order to represent angular and concentration dependencies, so that \( K(c - c_0)/(R_g - R_0) \) is plotted against \( \sin^2(\theta/2) + a \) \((c - c_0)\), where \( a \) is an arbitrary constant for adjustment of the envelope shape. This is because the reciprocal particle scattering factor can always be related to the radius of gyration, \( R_g \), of the solute particle through

\[ P^{-1}(\theta) = 1 + \frac{1}{3} \mu^2 R_g^2 \]

if \( \mu \) or \( \theta \) is small, and also because the reciprocal structure factor at zero angle, or the reciprocal increment of reduced intensity at zero angle, can be written in the form of virial expansion, which can be cast into

\[ S(0) = 1 - 2 B M_w (c - c_0) \]

if \( c - c_0 \) is small, where \( B \) is the second virial coefficient.

Equation (3) indicates that \( P^{-1}(\theta) \) increases with increasing \( \mu \) or \( \theta \), and equation (5) shows that \( S^{-1}(\theta) \) decreases with increasing \( \theta \) or \( \mu \) and depends on the micelle concentration, \( c - c_0 \). Then there are two limiting cases of angular dependence of the reciprocal envelope at a given concentration, as shown in Figure 1.

(a) If the external interference is weak and \( S(0) = S(\theta) \), then \( K(c - c_0)/(R_g - R_0) \) increases at higher angles. This behavior has been observed for dilute micellar solutions of most surfactants, both spherical and rodlike.

(b) If the internal interference is weak as compared with the external interference, or if only the external interference is strong, the reciprocal envelope shape, or if \( P(\theta) = 1 \) then \( K(c - c_0)/(R_g - R_0) \) decreases at higher angles, dependent on the micelle concentration, \( c - c_0 \).

Usually, instead of the case (b), the two effects of interference are combined, the Zimm plot should appear as given in Figure 2, depending on whether the external interference is comparable with or much stronger than the internal interference.

**RODLIKE MICELLES AT HIGHER IONIC STRENGTHS**

Since the (rodlike) micelles of dimethyloleylamine oxide are large and comparable with the wavelength of light, internal interference always occurs. The micelle molecular weight ranges from 1 million to 18 million, as will be seen below.

In the presence of NaCl more than 10^{-3} M, the light scattering behavior is normal, and the reciprocal envelope rises with increasing scattering angle. Figure 3 shows the Zimm plot of light scattering from the micellar solutions in the presence of 0.05 M NaCl with different HCl concentrations. The plot increases linearly at low angles, when the micelle concentration is low, but it increases convex upward at high angles,
Figure 1. Angular dependence of reciprocal envelope of light scattering. (a) $P^{-1}(\theta)$, (b) $S^{-1}(\theta)$.

Figure 2. Behavior of Zimm plots with different combinations of internal and external interference.

Figure 3. Zimm plots of light scattering from the micellar solutions of dimethyloleyleamine oxide in the presence of 0.05 M NaCl. The curves from left to right correspond to the micelle concentrations, $c - c_0 (10^{-2} \text{ g cm}^{-2})$: (a) 0.05 M NaCl; 0.008, 0.018, 0.047, 0.063, 0.092, 0.121, 0.163. (b) $10^{-2}$ N HCl + 0.05 M NaCl; 0.026, 0.053, 0.098, 0.129. (c) $10^{-3}$ N HCl + 0.05 M NaCl; 0.015, 0.027, 0.038.

Figure 4. Debye parameters: rodslike.

Figure 4 shows the radius of gyration of micelles. The second virial coefficient becomes zero and that the apparent weight-average micelle parameter is decomposed into two liquid phases.

Table I lists the critical micelle parameter. These values can be obtained from the extrapolation of the relevant reciprocal envelope.

Figure 4 the Debye parameter, large rodlike dependence equilibrium, and it shifts for micelle at higher...
when the micelle concentration is high. This behavior is interpreted as subject to the internal interference alone, so that the case (a) above holds true.

Equation (1), together with equations (6) and (7), indicates that the extrapolation of the Zimm plot to zero angle gives the reciprocal of apparent micelle molecular weight at a given micelle concentration, and that its initial slope yields the radius of gyration of micelle. The extrapolation gives the Debye plot, as shown in Figure 4 (a), and the radius of gyration is also given as a function of micelle concentration in Figure 4 (b).

Figure 4 shows that both the apparent molecular weight and radius of gyration of micelles increase with increasing-micelle concentration and reach constant values above $0.10 \times 10^{-2}$ g cm$^{-3}$. This suggests that the second virial coefficient, B, of the solution is small and negligible, and that the apparent micelle molecular weight is approximately equal to the weight-average molecular weight of micelles. In $10^{-3}$ N HCl these micelle parameters did not attain constant values before phase separation into two liquid phases occurred at high micelle concentrations.

Table I lists the constant values of molecular weight and radius of gyration of micelles, together with the aggregation number, $m = M_w/311.6$. These values can be assigned to the large rodlike micelles formed above the critical micelle concentration. It was not necessarily possible to obtain the corresponding values at the critical micelle concentration by extrapolation. Table I also includes the values of $(\mathrm{dn}/\mathrm{dc})_0$, $C_A/C_S$, and $c_0$.

Figure 4 then shows that small spherical micelles are formed at the critical micelle concentration and, with increasing micelle concentration, large rodlike micelles are also formed. Thus a concentration-dependent equilibrium would exist between spherical and rodlike micelles, and it shifts from the side of spherical micelle to that of rodlike micelle at higher micelle concentrations.
Similar angular and concentration dependences of light scattering were observed for the micellar solutions in the presence of 0.01 M NaCl with different HCl concentrations, and the micelle molecular weight and radius of gyration were derived from them.

Table I. Micellar Properties of Dimethyloleylamine Oxide in 0.05 M NaCl

<table>
<thead>
<tr>
<th>C_A (d^2I/dc)</th>
<th>c_A</th>
<th>c_o</th>
<th>M_w</th>
<th>m</th>
<th>R_G</th>
</tr>
</thead>
<tbody>
<tr>
<td>(M)</td>
<td>(cm^-3 g^-1)</td>
<td>(10^-2 g cm^-3)</td>
<td>(10^6)</td>
<td></td>
<td>(A)</td>
</tr>
<tr>
<td>0</td>
<td>0.161</td>
<td>0.003</td>
<td>6.90</td>
<td>22,100</td>
<td>1,270</td>
</tr>
<tr>
<td>10^-4</td>
<td>0.161</td>
<td>0.004</td>
<td>7.58</td>
<td>24,300</td>
<td>1,410</td>
</tr>
<tr>
<td>10^-3</td>
<td>0.167</td>
<td>0.004</td>
<td>(&gt; 15.0)</td>
<td>phase separation</td>
<td></td>
</tr>
</tbody>
</table>

MICELLAR SOLUTIONS AT LOWER IONIC STRENGTHS

In the absence of NaCl or its presence at a low concentration, the situation of light scattering is more complicated, and the reciprocal envelope varies with the scattering angle differently, depending on the micelle concentration as well as on the HCl concentration.

Figure 5 shows Zimm plots of light scattering from the micellar solutions in the absence of NaCl with different HCl concentrations. In water and 10^-4 N HCl, the plots decrease with increasing scattering angle, when the micelle concentration is high; but in 10^-3 N HCl the plot increases and levels off or passes a maximum with increasing angle, if the micelle concentration is low.

This behavior can all be adequately interpreted by assuming the strong effect of external interference, such as illustrated in Figure 2. Thus we have to distinguish the effect of external interference from the effect of internal interference, in order to derive the micelle parameters and the intermicellar interaction.

In 10^-3 N HCl the angular dependence of light scattering appears not to be very anomalous but to follow the normal behavior resulting from the internal interference alone. Nevertheless, its concentration dependence is very large, as can be seen from the wide range of observed values of reciprocal envelope. This behavior can also be explained by assuming that the effect of external interference is so strong that one-contact approximation does not hold well. Thus we have to rely on equation (1), instead of (7), for the analysis of the Zimm plots.

In order to separate the structure factor from the particle scattering factor, we have to postulate values of molecular weight and radius of gyration of micelle in equation (1). Then the value of \( P(\theta) \) can be calculated by means of equation (6) from the value of \( R_g \), and from the assumed values of \( M_w \), together with the calculated \( P(\theta) \) value, the value of \( S(\theta) \) can be derived by means of equation (1) from the observed value of \( R_g - R_0 \) at a given micelle concentration, \( c - c_0 \).

It can be shown that the structure factor, \( S(\theta) \), must satisfy the condition:
light scattering

of 0.01 M NaCl

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e Oxide in

R (A)

(A)

100 1,270
300 1,410

concentration, the

and the reciprocal en-

concentration.

e micellar con-

scattering

and 10^{-3} N HCl the plot

creasing angle, if

by assuming the

ference from the

e micelle para-

scattering appears not

resulting from the

tration dependence

values of

ed by assuming

that one-contact

on equation (1),

pitation weight and radius

ue of P(θ) can be

G, and from the

value of the

the observed value

must satisfy the

Figure 5. Zimm plots of light scattering from the micellar solutions of dimethyloleylamine oxide in water, 10^{-1} N and 10^{-3} N HCl without added NaCl. The curves from top to bottom correspond to the micelle concentrations, c - c_o (10^{-2} g cm^{-3}): (a) H_2O; 0.107, 0.072, 0.042, 0.006. (b) 10^{-3} N HCl; 0.103, 0.077, 0.044, 0.016, (c) 10^{-1} N HCl; 0.132, 0.106, 0.072, 0.038.

\[
\int_0^\infty [S(θ) - 1] \mu^2 dμ = -2 \pi \beta \frac{N_A (c - c_o)}{M_w}
\]  

From the Fourier transform of equation (5), we have

\[
g(\tau) = 1 + \frac{M_w}{2 \pi^2 N_A (c - c_o)} \int_0^\infty \frac{\sin \mu \tau}{\mu} \mu^2 d\mu
\]

under the requirement

\[
g(\tau) = 0
\]

Thus we have to examine whether the derived values of S(θ) for assumed values of M_w and R_G satisfy equation (8) or not. If they do not, we have to revise the set of values for M_w and R_G and to repeat the above procedure.

In this way we can find reasonable values of M_w and R_G for micellar solutions in water, 10^{-1} N and 10^{-3} N HCl, as given in Table II. Corresponding data of S(θ) for the micelles in water are plotted in Figure 6.

Then we can derive the radial distribution function of rodlike micelles in solution by means of equation (9). Figure 7 illustrates some of them. Each of them has a small hump around 1,400 - 1,650 Å. This means that the mean potential acting on a rodlike micelle has a minimum there. Since the mean potential is given by
Table II. Micellar Parameters of Dimethyloleylamine Oxide in the Absence of NaCl.

<table>
<thead>
<tr>
<th>C_a (N)</th>
<th>(d\theta/da)</th>
<th>C_A, C_S</th>
<th>C_0 (10^{-2} g cm^{-3})</th>
<th>M_w (10^6)</th>
<th>m</th>
<th>R_g (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.163</td>
<td>0.004</td>
<td>0.89</td>
<td>2,900</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>10^{-4}</td>
<td>0.162</td>
<td>0.004</td>
<td>0.83</td>
<td>2,700</td>
<td>390</td>
<td></td>
</tr>
<tr>
<td>10^{-3}</td>
<td>0.167</td>
<td>0.004</td>
<td>0.89</td>
<td>3,100</td>
<td>440</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6. Structure factor, S(0), vs. \mu for the micellar solutions of dimethyloleylamine oxide in water. Surfactant concentrations are as indicated from top to bottom.

Figure 7. The radial distribution function of the rodlike micelles of dimethyloleylamine oxide under different conditions.

\[ u(r) = -kT \ln \left( \frac{r}{r_m} \right) \]

The hump at \text{r}_m \text{corr} = 0.01 kT at 1,400 K is Boltzmann's constant. The former is a derivative of the Debye plot or equation (7).

From Table III, the molecular weight of the finite micelle increases moderately with increasing ionic strength in the static shielding in water.

It is clear that the hydration of amine species, as well as the salt, acts as the intermicellar repulsive force in solution but in the intermicellar region 10^{-4} N and 10^{-3} N HCl.

In 10^{-4} N HCl, molecules and N-hydroxyammonium 16 and in the presence of species is present effect of added NaCl, it is contributed to the electrostatic salting-out effect, which promotes their hydration, which is to the intramicellar semiflexible.

Thus the intermicellar repulsive force in solution but in the intermicellar region 10^{-3} N HCl, molecules and N-hydroxyammonium 16 and in the presence of species is present effect of added NaCl, it is contributed to the electrostatic salting-out effect, which promotes their hydration, which is to the intramicellar semiflexible.

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Thus the intermicellar repulsive force in solution but in the intermicellar region 10^{-3} N HCl, molecules and N-hydroxyammonium 16 and in the presence of species is present effect of added NaCl, it is contributed to the electrostatic salting-out effect, which promotes their hydration, which is to the intramicellar semiflexible.
The hump at r corresponds to the minimum of the potential well, where k is Boltzmann's constant and T is the temperature. The values of \( u(r) \) are \(-0.01\, kT\) at 1,400 A in water and \(-0.06\, kT\) at 1,650 A in \(10^{-3}\) N HCl.

**Molecular Weight of Micelles and Their Mutual Interaction**

Table III summarizes values of the molecular weight, aggregation number, radius of gyration of rodlike micelles, together with values of the minimum of mean potential of the intermicellar interaction. It also includes the values of the second virial coefficient, either derived from the Debye plot or from the structure factor at zero scattering angle. The former is a direct method usually made, and the latter has to rely on equation (7).

From Table III it can be seen that the micelles are all rodlike at the finite micelle concentrations. The micelle molecular weight increases moderately with increasing NaCl concentration, owing to the salting-out effect in water, and \(10^{-3}\) N HCl, and to the effect of electrostatic shielding in \(10^{-3}\) N HCl.

It is clear that the size-limiting factor of the rodlike micelles is hydration of amine oxide group, and, possibly, also of N-hydroxyammonium group, as well as the exchangeability of constituent molecules or ions in them. The salting-out effect of NaCl is to reduce the hydration that acts as the intermicellar repulsion.

In \(10^{-4}\) N and \(10^{-3}\) N HCl, the protonation of amine oxide group does occur to form N-hydroxyammonium group, as is manifest in the pH titration. The protonation of micelles could reduce the micelle size owing to the electrostatic repulsion, but the coexistence of both amine oxide and N-hydroxyammonium also has some effect of increasing the micelle size due to the intramicellar hydrogen bonding.

In \(10^{-3}\) N HCl the effect of hydrogen bonding between amine oxide molecules and N-hydroxyammonium ions in a micelle is strong, especially in the presence of NaCl, because an equal number of moles of the two species is present and is most favorable for the hydrogen bonding. The effect of added NaCl on micelle growth is appreciable. It cannot be attributed to the electrostatic shielding alone but must be caused by the salting-out effect. The dehydrogenation of amine oxide and N-hydroxyammonium promotes their hydrogen bonding within a micelle, thus stabilizing large micelles. In the presence of 0.01 M NaCl this effect is quite large. Further addition of NaCl forms too large micelles which cannot be stable in solution but induce separation of solution into two liquid phases. The molecular weight of micelles would not exceed 20 million in solution. The two liquid phases are both isotropic, so that rodlike micelles are semiflexible.

The second virial coefficient of micellar solution stands for the intermicellar repulsion, and its decrease with an increase in NaCl concentration must be attributed mainly to the dehydrogenation of amine oxide group, and, probably, also of N-hydroxyammonium group.

Thus the intermicellar interaction potential in aqueous solutions of dimethylolamylamine oxide in the absence and presence of HCl and NaCl at low concentrations arises mainly from the repulsive hydration and the van der Waals attraction of semiflexible rodlike micelles. The radial distribution function of micelles represents nonrandom arrangements of micelles clustering at the potential minima.
Table III. Molecular Weight, Aggregation Number, Radius of Gyration of Rodlike Micelles, and Depth of Their Mean Potential in Solution and Second Virial Coefficient of Micellar Solution.

<table>
<thead>
<tr>
<th>$C_A$ (N)</th>
<th>$\alpha$</th>
<th>pH</th>
<th>$C_S$ (M)</th>
<th>$M_w$ ($10^6$)</th>
<th>$R_G$ (Å)</th>
<th>$u(r_m)$ -0.01 kT</th>
<th>$2B$ ($10^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>2.900</td>
<td>250</td>
<td>0.83</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>2.700</td>
<td>390</td>
<td>-0.04</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>3,400</td>
<td>440</td>
<td>-0.06</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.89</td>
<td>0.83</td>
<td>0.98</td>
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</tr>
<tr>
<td>$10^{-4}$</td>
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<td>3,300</td>
<td>300</td>
<td>-0.01</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.03</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$5 \times 10^{-4}$</td>
<td></td>
<td></td>
<td></td>
<td>4,720</td>
<td>560</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>1.47</td>
<td>560</td>
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</tr>
<tr>
<td>$10^{-3}$</td>
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<td></td>
<td></td>
<td>8,670</td>
<td>850</td>
<td>-0.04</td>
<td>0.40</td>
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<td>1.49</td>
<td>420</td>
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<td>0.214</td>
<td>0.214</td>
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</tr>
<tr>
<td>$10^{-2}$</td>
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<td>15,300</td>
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<td>16,000</td>
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SUMMARY

Dimethyloleynamine oxide forms large rodlike micelles in aqueous solutions, and their molecular weight and mutual interaction are strongly influenced by the addition of HCl up to $10^{-3}$ N and also by the addition of NaCl up to 0.05 M. In water nonionic micelles are present, while in 10^{-3} N HCl half-protonated micelles are formed.

In the presence of NaCl less than 0.01 M or in its absence, the micelle has molecular weight of 1 to 2 million, and these micelles interact strongly and are arranged nonrandomly, thus exhibiting strong external interference in light scattering.

In the presence of NaCl at 0.01 M and 0.05 M NaCl, the micelle mole-
The observed behavior of large rodlike micelles may be explained by the formation of intramicellar hydrogen bonding between amine oxide and N-hydroxyammonium and the dehydration of the head groups by the salting-out effect of NaCl.

REFERENCES

14. T. Imae and S. Ikeda, these Proceedings, previous paper.