During the last two decades considerable attention has been given to minimize the evaporation loss of water in lakes and reservoirs by spreading insoluble monomolecular films of normal, long chain fatty alcohols on water surface. A study of the various monolayer properties with particular reference to the permeability of water molecules through such films under different conditions of surface pressures and temperatures would provide valuable information about the structure of these films and also elucidate the effective resistance offered by them.

Among the more desirable properties, it may be mentioned that the film should be condensed, close-packed and incompressible. To maintain a close-packed monolayer, the film forming substance must have high equilibrium spreading pressure which would tend to prevent disruption of the film. It would also resist the entry of impurities which may reduce the evaporation resistance of the film. Also, it must have high rate of spreading to facilitate the covering of the water surface with a monolayer, and healing up of damaged films caused by any extraneous causes such as evaporation and dissolution of the film molecules or by any mechanical effect. The film must be elastic to
allow the expansion and contraction without breakage when ripples are formed on the surface of water, for example, by wind moving over the surface. At the same time there should be strong anchorage of the film molecules on the subphase water to prevent their piling up on a side of the reservoir by the breeze. The rheological behaviour such as shear and compressibility of the film become an important consideration in this connection. Further, a knowledge of the various types of phases formed during the compression of the film to different extents in relation to the packing property of the film molecules is required for understanding the permeability and stability of the monolayers.

It is well known that monolayer forming substances which are inherently the best water evaporation retardants have long, straight hydrocarbon chain with a small polar group (-OH) at one end. Thus cetyl alcohol (n-hexadecanol, designated as C\textsubscript{16}-OH) and stearyl alcohol (n-octadecanol, designated as C\textsubscript{18}-OH) which combine high resistance with a high equilibrium spreading pressure and a suitably high spreading rate, have been most extensively studied and being tried in field experiments for conservation of stored water.

In a programme of studies on water evaporation control by spreading insoluble monolayers on water surface in our laboratory, a series of alkoxyethanols of the type CH\textsubscript{3}-(CH\textsubscript{2})\textsubscript{n-1}OCH\textsubscript{2}CH\textsubscript{2}OH (designated as C\textsubscript{n}-CCH\textsubscript{2}CH\textsubscript{2}OH with
n = 16-22) has been found to have much superior evaporation reduction properties to the corresponding fatty alcohols. With a view to elucidate their behaviour the monolayer properties including a few bulk properties of these compounds on water surface are, therefore, being extensively studied in our laboratory using a variety of techniques such as pressure-area isotherms, surface potentials, X-ray diffraction and electron microscopy. Measurements of surface viscosity are especially useful in the investigation of the nature and structure of monolayers as it provides many important and relevant informations regarding the surface mechanical properties including compressibility, elasticity and flow behaviours of the films, phase transitions, stability of the film and the nature of molecular interactions between the molecules and their relaxation properties. In this thesis we are reporting the results of our surface viscosity study of the monolayers of the fatty alcohols and the alkoxy ethanols on water surface at different temperatures and surface pressures.

Before we present the results, it is desirable at this stage to present a brief review of the literature on the subject with particular reference to the insoluble monolayers formed by these type of compounds. An excellent review article on surface viscosity has been published recently by Joly\(^1\). However, it deals mainly with the behaviour of protein and polymer monolayers.
The resistance of a fluid substance to deformation has been noted by Plateau\textsuperscript{2,3} who inferred the existence of a surface viscosity from the difference in the damping rates of a compass needle oscillating on the surface and in the bulk of a liquid. A difference in surface tension appears on both sides of the needle which contributes to its damping. This observed phenomenon is the result of many complicated effects such as shear viscosity and dilational viscosity\textsuperscript{4}. We are interested only in certain aspects of the rheological behaviour of surface layers which are useful in the study of insoluble monolayers.

For the uncontaminated surfaces of pure liquids, the excess resistance is very small, but in the presence of a contaminant such as a dissolved surface active substance or insoluble monolayer, it can become appreciable. If the area of the surface is altered at some finite rate, the surface layer may not adjust to its equilibrium configuration rapidly enough to maintain the equilibrium surface tension. For an insoluble monolayer, there is no replenishment mechanism but in principle it is possible that relaxation processes may exist which will lead to a true dilative surface viscosity. Such a viscosity would be manifested among other time-dependent phenomena, as a compression-rate dependent hysteresis in compression-expansion cycle pressure-area ($\Pi$-$A$) measurements.
In addition to the resistance to deformation involving expansion or contraction of the surface, a film may possess a resistance to flow or shear in the plane of the surface at constant area and surface pressure. The rheological properties of such layers are analogous to those of matter in bulk. Some films behave as a simple liquid which flows as soon as a shear stress is applied. Their flow property may therefore be characterised by a coefficient of shear viscosity ($\mu$) defined by Joly\textsuperscript{5,6} as follows: A small element $dxdy$ of monolayer, flowing in its plane $xy$ with a velocity $u(y)$ in the direction $x$, undergoes from the adjacent monolayer elements a resisting force equal to

$$\mu \frac{d^2u}{dy^2} \ dx \ dy$$

In other words it is the ratio of the shear stress to the rate of flow of the film. Such films may be either Newtonian, exhibiting surface viscosity independent of shear rate, or non-Newtonian, having viscosities varying as a function of the rate of flow. Some films, however, are two dimensional solids, and can deform elastically. Many films exhibit also complex viscoelastic behaviour. However, since our interest is to relate flow properties of a film to the nature of the film molecule itself, eliminating or correcting for the effects of the subphase, we shall only be concerned with experimental measurements of relative viscosity only.
Early studies on surface viscosity were chiefly concerned with insoluble monolayers of relatively simple molecules, like aliphatic acids and triglycerides or long chain alcohols. In recent years, a relatively large number of papers have been published mostly on protein and high polymer monolayers. Also, the accuracy of the measurements has been improved. The more important experimental methods have been briefly described in Chapter-II.

The quantitative interpretation of surface viscosity data, in terms of molecular properties is still in an unsatisfactory state. Difficulties have arisen not only from theoretical limitations but also from uncertainty in the proper interpretation of experimental data. Except the work of Joly, most of the interpretations are of a qualitative nature. Some of the related earlier work is mentioned in the following.

Langmuir and Schaefer have measured the absolute surface viscosities of stearic acid and barium stearate films at different pH values of substrate, using damped oscillation method.

Myers and Harkins suggested that surface viscosity would be of great value in understanding the phenomenon of penetration of liquids into solids and rate of spreading of the films. They observed that the surface viscosity depends more on the extent of close-packing of the molecules in the
film than upon the number of carbon atoms in a chain. In a close-packed monolayer intermolecular forces are more predominant. They measured the surface viscosities of the cetyl alcohol and pentadecylic acid films on 0.01 m HCl at 25°C and found that cetyl alcohol film is tightly packed and pentadecylic acid forms an expanded film.

According to Joly\textsuperscript{10}, the viscosity of a monolayer is characterised by its state, structure and resistance to flow offered by the subphase liquid. Dervichian and Joly\textsuperscript{11} measured the viscosity of stearic acid and tricaproin by the canal method. The curve (rate of flow vs. surface concentration) showed angular points which correspond to different order of transformations in the monolayer.

Fourt and Harkins\textsuperscript{12} studied the surface viscosity of n-long chain alcohols (C\textsubscript{14}–C\textsubscript{18}) by the damped oscillation method, as a function of pressure, and showed that the surface viscosity relations are of the same general type. At low pressures, films behave as a Newtonian fluid and at high pressures they exhibit non-Newtonian viscosity i.e. the apparent viscosity decreases with increase in shear rate. The \( \mu \) increases with film pressure (\( \Pi \)) till a phase transformation from a liquid condensed (L\textsubscript{c}) to solid (S) state takes place, after which viscosity remains nearly constant. The break in the (\( \mu - \Pi \)) curve corresponds to a kink in the \( \Pi - A \) (\( A = \) area/molecule) isotherm.
Joly\textsuperscript{13} studied the effect of narrow and deep canal and capillary action on the viscosity of the film, and also the effect of subphase and vice-versa. He measured the surface viscosities of oleic acid, triolein, tribenzoin and stearic acid with canals of different width and observed that there is some interaction between film molecules and subphase.

Trapeznikov\textsuperscript{14} measured the mechanical properties such as surface viscosity and elasticity of the films of palmitic acid, oleic acid and cetyl alcohol on water subphase. He observed that oleic acid films exhibit very low viscosity and addition of multivalent cations to the substrate causes solidification of palmitic acid films.

The earliest attempt to produce a theory of molecular mechanism in monomolecular films was that of Moore and Eyring\textsuperscript{15}. Their theory is an extension of the equation for fluidity of liquids based on the Eyring's reaction rate theory of viscous flow in bulk liquids. The free energy of activation for viscous flow in surface films as calculated from the viscosity data of Harkins and Myers\textsuperscript{3} and Langmuir and Schaefer\textsuperscript{7} was found to be about twice that for the flow of liquids in bulk. This may be due to the occurrence of various types of association in liquid films.

Boyd and Harkins\textsuperscript{16} measured the surface viscosity of fatty acid monolayers (C\textsubscript{15}-C\textsubscript{20}) on aqueous subphase.
and showed that it is highly dependent on the pH of the subphase and type of packing of molecules in a film. Further it was shown that the surface viscosity data reveal the existence of phase transformations which are not apparent from other measurements such as $\Pi - A$ isotherms and $\Pi - \Delta V$ ($\Delta V$ = surface potential) curves. The liquid condensed ($L_c$) film exhibited Newtonian viscosity. They observed that the viscosity increases as the chain length increases as also with the pressure. The effect of temperature on arachidic acid monolayer has also been studied.

Dervichian and Joly have shown that higher order transformations can be detected by measurements of the compressibility, viscosity and apparent electric moment. These are characterised by a sudden change in viscosity or electric moment.

Nasini and Mattei adopted the measurements of surface viscosity amongst various other properties such as $\Pi - A$ and $\Delta V - \Pi$ isotherms, as it can be interrelated with the forces acting between the film molecules and between molecules of the film and subphase.

Nutting and Harkins measured the surface viscosity of stearic acid and n-long chain alcohols (15-18 carbon atoms) by several types of canal viscometers. The viscosity
increased with the molecular weight. The viscosity of heptadecyl alcohol was slightly greater than that of hexadecyl alcohol, while the two are considerably separated from both penta- and octadecyl alcohol.

Alexander gave a brief survey of the possible methods of measuring changes in interfacial tension, viscosity and potential brought about by spreading insoluble monolayers at oil/water interface.

Trapeznikov measured the surface viscosity of octadecyl alcohol at different temperatures on 0.01N NaCl and water using the damped oscillation method. The curve viscosity vs pressure gave a sharp break at a pressure of ~13 dynes/cm.

Harkins et al. discovered a new phase called liquid solid (L3) as observed in the Π-A isotherm for C_{18}-OH and C_{20}-OH. This phase shows a suparmobile character corresponding to a slightly flat portion in the Π-A isotherm. This was observed only for a particular compound and at a particular temperature. The compressibility of this phase is more or less equal to that of the solid (s) phase. The existence of this phase is always accompanied by a decrease in surface viscosity. They have also observed that the increase in the transition pressure due to the increase in the number of carbon atoms as indicated in the Π-A isotherm is also revealed in the surface viscosity measurements. In the s and L3 phases the molecules are assumed
to be oriented perpendicular to the surface. They attributed the decrease in the viscosity to the presence of the L3 phase resulting from a strong hydrogen bonding interaction between film molecules themselves and a weaker interaction between film molecules and water subphase.

Trapeznikov\textsuperscript{26,27} measured the two dimensional surface viscosity of octadecanol by the damping of vibration of a disc suspended by an elastic wire, on aqueous C.CIN NaCl as a function of pressure, and at different temperatures. He observed that (μ-Π) curves show a minima followed by a maxima at about 13 dynes/cm. Two distinct portions of the curve were suggested to correspond to different modifications and not to two different two dimensional states of aggregation. He considered the state of the monolayers of higher alcohols at high pressure (∼40 dynes/cm.) usually described as solid condensed, as a liquid crystalline state. According to him the two dimensional phase designated by Copeland and Harkins\textsuperscript{24} as a new L3 (liquid solid) phase in reality does not differ fundamentally from the other crystalline state (Trapeznikov,\textsuperscript{26}) at t > T_C (t = experimental temperature and temperature T_C marks the boundary between crystalline and liquid crystalline states of monolayer or melting point of liquid crystalline film. The rapid increase in surface viscosity in a homologous series with increase in chain length was explained as due to part played by van der Waals energy of interaction between chains.
Joly, following the theory of Eyring, calculated the activation energy for flow of various monolayers mainly on the basis of van der Waal forces and assigned structures at different equilibrium positions. The energy of interaction between various functional groups of neighbouring molecules was calculated from calorimetric data. He assumed that the molecules in a film are arranged in a quasi-hexagonal lattice and there is a free rotation of molecules around the normal to the surface of water at every point in the lattice. The free energy of activation ($\Delta F$) can be written in the form of a modified equation of Eyring,

$$\mu = \frac{h}{\sigma} e^{\frac{\Delta F}{kT}} \cdots (1.1)$$

$\Delta F$ is the energy necessary to make the molecule of the film pass from one position of equilibrium to another neighbouring position. He resolved this energy into two terms:

(i) The energy which is required for making a hole in the monolayer so that neighbouring activated molecule can enter,

(ii) The energy required for making a molecule pass from one equilibrium position to another neighbouring place. The latter comprises of three terms: (i) energy of translation of a molecule, (ii) energy of deformation of the lattice and (iii) energy of change of state of equilibrium of the molecule. Finally, the value for ($\Delta F$), the free energy of activation is given by the relation,

$$\Delta F = W_{1r_i} + \Theta_{1-k}(r_i) + 6 \left[W_{1r_i} - W_{1-k}(r_i)\right] \cdots (1.2)$$
where \( \omega_i r_1 \) is the energy necessary to make a hole in the monolayer, or energy of interaction in the state \( i \) with spacing \( r_1 \), \( \theta_{i-k}(r_1) \) is the energy required for the displacement of the molecule from an initial state \( i \) to a state \( i-k \), and \( 6 \left[ \omega_i r_1 - \omega_{i-k}(r_1) \right] \) is the energy required for activating mobile molecule, \( 3 \left[ \omega_i r_1 - \omega_{i-k}(r_1) \right] \) for three molecules under consideration and a similar quantity for the surrounding lattice. He found good agreement between experimental and calculated values of \( (\Delta r') \) for oleic acid and tricaprin.

Joly\(^{29}\) measured the surface viscosity of the films of a number of fatty acids, esters and n-long chain alcohols on water and very dilute solutions of HCl, by both the canal and damped oscillation methods. In general surface viscosity of aliphatic compounds was found to decrease with increase in temperature. The effect of surface concentration is notable, \( \mu \) decreasing in gaseous and liquid films, increasing in mesomorphic films as surface concentration increases.

A general theory was proposed by Joly\(^{30}\) on the transformations of different orders in monolayers based on the study of different properties such as \( \Pi-A \), \( \Delta \mu-\Pi \) and \( \Delta V-\Pi \) isotherms. It was suggested that molecules in monolayer can exist only in a definite number of energy states corresponding to discrete series of molecular forms or molecular areas, these being precisely the areas of points of transformation. The transformations of different orders
correspond to the discontinuous passage from one molecular form to another. The order of transformation depends on the miscibility or non-miscibility of successive molecular forms. This structure theory was applied to calculate the activation energy of flow. A theory on phase changes induced by different velocity gradient and also the effect of time on surface viscosity was also put forward.

Chaminade et al. constructed a rotational viscometer for measuring the viscosity of compounds exhibiting non-Newtonian character. The viscosity was measured for cetyl alcohol and stearic amide as a function of shear rate and found that the viscosity decreases in the case of both compounds with increase in shear rate.

Joly studied the surface viscosity of films of n-long chain alcohols (C_{12}-OH to C_{14}-OH) and stearamide as a function of shear rate and pressure and noticed that at every transition, there is an abrupt change in surface viscosity. It has also been shown (Joly) that surface rheology study gives us the possibility of developing an accurate experimental basis for a simple molecular flow process, by which rheological behaviour of monolayers can be quantitatively described.

Mukherjee attempted to find out a relationship between surface viscosity of condensed films with surface pressure and area per molecule. Ree and Eyring have
developed an equation for non-Newtonian flow of solid-plastic film by considering the following factors: (i) relaxation time of flow units, (ii) distribution of such relaxation times and (iii) deformation of system with stress.

Joly explained the results of surface rheology with the help of simple molecular model of flow behaviour of monolayers. The fundamental processes of this rheological pattern are: (i) the transport of surface molecules rigidly bound to molecules of flowing monolayer, (ii) the deformation by the flow of quasi lattice structure of the film, the relaxation velocity of which determined a type of behaviour, Newtonian or not, in relation to the rate of shear and interaction energies between kinetic unit, and (iii) the microscopic or macroscopic phase changes induced in the monolayer by the flow causing, for instance, the shear hardening phenomenon, the various time effects and decrease of apparent molecular area. The above three types of processes are correlative and simultaneous. As a consequence of reciprocal interaction between structure and rate of shear, the actual flow behaviour of a monolayer depends upon its total rheological history.

Rosano and La Mer studied the specific resistance to evaporation and surface viscosity, for monolayers of n-long chain esters, acids and alcohols, as a function of surface pressure. They could not find any direct
relationship between surface pressure, surface viscosity and specific resistance to evaporation. The plots of surface viscosity and specific resistance to evaporation versus surface pressure showed the same slope at any given pressure. The discontinuity in the slope of the above curve have been ascribed to a change of phases in the monolayers.

Joly\textsuperscript{37} has reviewed the phase changes induced by shearing in monolayers with reference to his previous work.

Jarvis\textsuperscript{38} studied the surface viscosity of 14, 16 and 18 carbon chain aliphatic amines, alcohols and amides, using a canal viscometer as a function of film pressure, pH of the substrate, and the rate of flow of the film. He has shown good agreement between his results and those reported in the literature. By varying the width of the canal, the effect of shear rate on surface films on its surface viscosity was studied. It was observed that above an average pressure of 6 dynes/cm., surface viscosity of tetradecanol and hexadecanol have a marked dependence on the rate of shear. The octadecanol appeared to be Newtonian up to a film pressure of 20 dynes/cm. at the flow rates studied (0.02 to 0.2 cm\textsuperscript{2}/sec.).

Katti et al.\textsuperscript{39} have studied the surface viscosity of monomolecular films of n-long chain alcohols and n-alkoxy ethanols at 25°C, at the liquid condensed to solid
(L_c\rightarrow 3) transition pressure region, and at different shear rates. All the monolayers exhibited non-Newtonian character. The free energies of activation for viscous flow and relaxation times were calculated by extrapolating the viscosity at zero and infinite shear rate.

Since we are interested in investigating the possible existence of various phases in the monolayer states of long chain alcohols and alkoxy ethanols on water surface using surface viscosity - surface pressure isotherms, it is desirable to mention the reported results in the literature on various types of phases identified in such cases, particularly from \( \Pi - A \) isotherm studies.

Devaux pointed out that molecules in monomolecular film exist in different two dimensional states, which are analogous to three dimensional solid, liquid and gas. The \( \Pi - A \) isotherms are found to exhibit various two dimensional phases starting from the perfect gas phase at extremely large values of area per molecule and going over, on progressive reduction of area, into imperfect gas, and then for low enough temperature into a condensed phase in some way analogous to three dimensional systems. In the case of a monolayer, however, several different liquid phases are observed. All the phases may not be observable with any single substance at one temperature. Therefore, to investigate the possible existence of different phases, one should examine the different members of homologous
series at one temperature or else examine the same substance over a wide temperature range. A general diagram of $\Gamma-A$ isotherm indicating all the observed phase changes during the compression of the monolayer is given (Fig. 1A).

The various monolayer states represent different degrees of freedom or order resulting from the intermolecular forces in the film and subphase.

The order of phase change can be found according to Ehrenfest as follows:

If $\sigma_f$ is the surface tension of the film covered surface and $\sigma_w$ that of clean water surface, separated by a barrier, the work done by the film during infinitely small change of area $dA$, is

$$dW = (\sigma_w - \sigma_f)dA = \Pi dA . \quad \ldots (1.3)$$

Now, if $S$ is the total entropy of the system and $E$ the internal energy,

$$dE = dQ - dW = TdS - pdv - \Pi dA \quad \ldots (1.4)$$

and Gibbs free energy is,

$$G = E - TS + pv + \Pi A .$$

Therefore,

$$dG = - 3dT + vdp + A d\Pi \quad \ldots (1.5)$$
Now the order of phase change is given by the lowest derivative of the free energy of the system which exhibit a discontinuity. Therefore,

\[
\left( \frac{dG}{dt} \right)_{p,T} = A
\]

or

\[
\left( \frac{dG}{dT} \right)_{p,A} = -3
\]

Thus a discontinuity in area at constant pressure and temperature or in entropy (absorption of heat - latent heat) is a first order change. In this case, the isotherm will run during the phase change parallel to the area axis. Again,

\[
\left( \frac{d^2G}{dT^2} \right)_{p,T} = \left( \frac{dA}{dT} \right)_{p,T}
\]

Therefore, a discontinuity in the compressibility shows a second order change. In this case, the isotherm shows a sudden change in the slope at the point of transformation.

Similarly, a discontinuity in the third order derivative shows a third order change. In this case isotherm may not apparently indicate a phase change. However, the compressibility when plotted against the area will show a sudden change in slope. A brief description of various two dimensional phases observed in different monomolecular films is given below:
Gaseous or Vapour Films (G)

Langmuir\(^4^1\) was the first to predict the existence of gaseous film, which occurs at large molecular areas. The molecules in this phase are floating about in the surface layer far enough apart so that they exert relatively little force on one another, and obeys the perfect gas law \( \bar{\Pi} = kT \), where \( \bar{\Pi} \) is the film pressure (dynes/cm.), \( k \) the area per molecule (in \( \text{A}^2 \)), \( k \) the Boltzmann's constant and \( T \) the absolute temperature (\(^\circ\)K). The molecules in the gaseous monolayer lie nearly flat with respect to the water surface.

Constant Vapour Pressure Region

As the area/molecule is decreased, the film pressure starts increasing and at the same time the gaseous film becomes imperfect, and provided the temperature is below a certain critical value \( (T_c) \), one observes a constant vapour pressure region and a film transforms by a first order change into a condensed phase (van der Waal's condensation).

Vapour Expanded Films (\(V_g\))

There are certain films such as ethyl esters, as reported by Adam\(^4^2\) which do not transform into the constant vapour pressure region but pass continuously into a condensed state. These are called vapour expanded films.
All the films should exhibit this behaviour above their respective two-dimensional critical temperature. In the case of collapse of vapour expanded films (and in some cases liquid expanded films also) on sufficient compression, it was found by Dervichian\textsuperscript{43} that the surface tension of the film-covered water surface at the collapse point ($\gamma_e$) corresponded to the sum of the surface tension of the film forming liquid ($\gamma_R$) and its interfacial tension with water ($\gamma_{RW}$).

$$
\gamma_e = \gamma_R + \gamma_{RW} \quad \text{(experimentally)} \quad \ldots \quad (1.8)
$$

Thus by collapsing, the surface film passes continuously into the three-dimensional liquid.

**Liquid Expanded Films (L\textsubscript{e})**

Labrouste\textsuperscript{44} was the first to observe this phase which is obtained by a further decrease in area beyond the constant vapour pressure region below the two-dimensional critical temperature. This phase exhibited nearly hyperbolic relation between pressure and area.

**Intermediate Liquid Phase (I)**

On further decreasing the area of liquid expanded film, the film transforms by diffused first order or probably second order transformation into an intermediate liquid state. The main feature of this phase is its relatively very high compressibility at higher values of
area/molecule, with the isotherm in some cases running almost parallel to the area axis.

Condensed Liquid Phase (Lc)

As the intermediate phase is compressed the pressure rises more and more rapidly and the compressibility decreases till the curve changes to a straight line and the intermediate phase transforms by a third order or probably second order transformation into the Lc phase.

Liquid-Solid Phase (L3)

As the pressure is increased further in the liquid condensed state, in a narrow temperature range there exists a short flat region where the film transforms into a highly condensed state, called an L3 phase. Harkins et al. 24,25 were the first to observe this phase while studying the \( T-A \) isotherms of condensed monolayers of \( n \)-long chain alcohols. They reported that this phase had a high fluidity. Thus they named this phase as L3 because it possessed a fluidity similar to a liquid condensed film and compressibility of a solid film. The L3 phase exhibits low viscosity compared to that of the liquid condensed phase. In the present work L3 phase is obtained by both first order and second order transition depending upon the temperature. The L3 phase obtained by second order transition had a compressibility similar to that of the solid phase.
Solid Phase (3)

If a liquid condensed film is compressed further, it finally reaches the area sufficiently low to produce a change of phase by a second order transformation into what is usually designated as solid film having very low compressibility. In this phase the molecules of the film are close-packed and vertically oriented.

As indicated earlier we have studied the monolayer properties of a series of normal alcohols (C_{16} to C_{22}-OH) and alkoxy ethanols (C_{16} to C_{22}-OC_{2}H_{4}OH) by measuring their surface viscosities on water at different temperatures, surface pressures and shear rates using the continuous rotation method.

In what follows, the important methods of measurement of surface viscosity and that of the apparatus constructed and used by us are described (Chapter-II). Surface viscosity results of the fatty alcohols are reported in Chapter-III, followed by those of alkoxy ethanols given in Chapter-IV. The properties of the mixed monolayers of alcohols and alkoxy ethanols are given in the final Chapter-V.
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