

Chapter I
INTRODUCTION



1.1 General Study of Liquid Crystals¹

A group of organic compounds which exhibit one or more mesophases are called "liquid crystals". They are liquid in mobility yet solid in structure. This is accomplished by having crystal-like order in one or more directions and liquid-like disorder in the other spatial orientations. In excess of 1,500 compounds are known at present to exhibit liquid crystal properties.

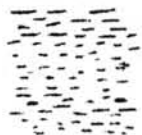
According to the molecular structure of the substance in the mesophase, they have been classified into three major classes, smectic, nematic and cholesteric as shown in Fig 1.1



Smectic



Nematic



Cholesteric

Fig.1.1 Molecular alignment of liquid crystals.

¹A. Saupe, "Recent Results in the Field of Liquid Crystals", Angew. Chem. Internat. Ed. Engl. 7(1968)97.

The smectic mesophase is characterized by having the molecules stratified, i.e. arranged in layers with long axes of the molecules approximately normal to the plane of the layer. The molecules can move in two directions in the plane of layer and rotate in that plane.

The molecular arrangements in the nematic mesophase are not in layers but molecules tend to be aligned parallel to each other. Molecular movements in the nematic mesophase are somewhat less restricted. They can occur in three directions in plane, and a rotation about the long axis.

The cholesteric mesophase is exhibited principally by the esters of cholesterol and is due to the helical stacking of the cholesterol plates. It may be regarded as a special case of nematic phase since its molecular structure corresponds to a twisted nematic.

Since the discovery of liquid crystals by Reinitzer in 1888, the literature has registered extensive entries both on experimental and theoretical ground. Several workers have reported anomalies in physical properties in liquid crystals, such as viscosity,² dielectric property³, specific heat⁴,

²M. Miezowicz, Nature, 136(1935) S261.

³E.F. Carr, "Dielectric Loss in the Liquid Crystal p-Azoxyanisole", The Journal of Chemical Physics, 37(1962)104.

⁴E.M. Barrall II, R.S. Porter and J.F. Johnson, "Specific Heats of Nematic, Smectic, and Cholesteric Liquid Crystals by Differential Scanning Calorimetry," The Journal of Physical Chemistry, 71(1967) 895.

density⁵ and ultrasonic properties⁶. These properties and interpretations of the structure of liquid crystal are not well understood.

Recently, the proton spin-lattice relaxation⁷ and self-diffusion⁸ of nematic liquid crystal were reported. Some inconsistencies^{7,9,10} among the reports are understood in term of impurity effect.¹¹

1.2 Scope of This Experiment

In this thesis, the proton spin-lattice relaxation time(T_1) and spin-spin relaxation time (T_2) of liquid crystal

⁵R. Schenck, Z. Physik. Chem., 25(1898) 343.

⁶W.A. Hoyer and A.W. Nolle, "Behaviour of Liquid-Crystal Compounds Near the Isotropic-Anisotropic Transition", The Journal of Chemical Physics, 24(1956)803.

⁷R.Y. Dong, W.F. Forbes, and M.M. Pinter, "Proton Spin Relaxation in Liquid Crystal PAA", Ibid., 55(1971)145.

⁸R. Blinc and V. Dimic, "Neutron Scattering Study of Self-Diffusion in Liquid Crystal", Physics Letters, 31A(1970)531.

⁹J.M. Doane and J.J. Visintainer "Proton Spin-Lattice Relaxation in Liquid Crystals", Physical Review Letters, 23(1969) 1421.

¹⁰R. Blinc, D.L. Hogenboom, D.E. O'Reilly and E.M. Peterson, "Spin Relaxation and Self-Diffusion in Liquid Crystals" Ibid., 23(1969)969.

¹¹R.Y. Dong, M.M. Pinter, and W.F. Forbes, "Proton Spin Relaxation Study of the Cholesteric-to-Nematic Phase Transition", The Journal of Chemical Physics, 55(1971)2449.

PAA (para-azoxyanisole) in the temperature range 380-450°K have been investigated. The pulse nuclear magnetic resonance method¹² was used in T_1 and T_2 measurement at proton resonance frequency 10 MHz. A series of 90° and 180°rf pulses were applied to induce an alternating magnetic field (H_1) perpendicular to a static magnetic field (H_0). With the appropriate pulses interval, the induced signal from the sample can be detected in various amplitudes which are used for calculating T_1 and T_2 . The detail principles of this measurement will be described in Chapter II.

The mechanisms contributing to T_1 and T_2 in nematic liquid crystals have been proposed to be the thermal fluctuation of the orientational order¹³ and a slow cooperative mode⁷ with a characteristic frequency $\omega_s \sim 10 \text{ sec}^{-1}$, in addition to the translation diffusion which is responsible for the relaxation in ordinary liquids. Our results of T_1 agree qualitatively with published results by Dong^{7,11} et al., Doane⁹ et al., and Weger¹⁴ et al.. These support the proposal that in the nematic

¹²H.Y. Carr and E.M. Purcell, "Effects of Diffusion on Free Precession in Nuclear Magnetic Resonance Experiments", Physical Review, 94(1954)630.

¹³P.Pincus, "Nuclear Relaxation in a Nematic Liquid Crystal" Solid State Communications, 7(1969)415.

¹⁴M. Weger and B. Cabane, J.Phys.Radium, 30(1969)c4-72.

phase, the relaxation mechanism is mainly the thermal fluctuation of the nematic order. Our results for T_2 which are nearly temperature independent support the proposal that in the nematic phase, the translation diffusion is very weak and nearly constant over the whole nematic range and in agreement with the results of neutron scattering method published by R.Blinco⁸ et al.

The details of experimental apparatus and procedure of this investigation will be given in Chapter III; discussions of the results will be found in Chapter IV.