

## LETTERS TO THE EDITOR

### CONFORMAL UNIQUENESS OF SCHWARZSCHILD INTERIOR SOLUTION

In this note we are interested in the following question :

Is a solution of Einstein's field equation for a perfect fluid distribution which is static and conformally flat, unique ?

For this purpose we consider the metric

$$ds^2 = e^{2\sigma} (dt^2 - dx^2 - dy^2 - dz^2)$$

where  $\sigma$  is a function of  $x, y, z$  only and the field equations

$$G_{\mu\nu} = -8\pi [(\rho + p)v_\mu v_\nu - pg_{\mu\nu}],$$

the symbols having their usual significance. The solution we find is

$$e^{-\sigma} = A(x^2 + y^2 + z^2) + B$$

$$\rho = \frac{3}{2\pi} AB$$

$$p = -\frac{AB}{\pi} + \frac{1}{2\pi}(x^2 + y^2 + z^2)$$

$$v_4 = e^\sigma, v_1 = v_2 = v_3 = 0,$$

where  $A$  and  $B$  are arbitrary constants. This is just the Schwarzschild interior solution in a different coordinate system. It should be noted here that the density comes out to be a constant which is assumed in the usual derivation of the solution.

In order to put this solution in the usual form all that we need is to put the solution in the  $R, \theta, \phi$  (spherical polar coordinates)

$$ds^2 = e^{2\sigma} (dt^2 - dR^2 - R^2 d\theta^2 - R^2 \sin^2 \theta d\phi^2)$$

$$e^{-\sigma} = AR^2 + B$$

and then carry out the transformation

$$R = \frac{1 \pm \sqrt{1 - 4ABr^2}}{2Ar}$$

This investigation along with the results obtained by Krishna Rao and Patel, R. B.<sup>1</sup> shows that Schwarzschild interior solution is the only solution of Einstein's equation for perfect fluid distributions which is static and conformally flat.

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### FLUOROMETRIC STUDY OF SOLUTIONS OF THIONINE

In an organic molecule usually the lowest lying state can be a  $\pi\pi^*$  or a  $\eta\pi$  state but invariably in a fluorescent organic molecule the lowest lying singlet state is a  $\pi\pi^*$  one<sup>1</sup>. The quantum yield of fluorescence of an organic molecule is a function of the relative positions of the lowest lying  $\pi\pi^*$  and  $\eta\pi^*$  singlet and triplet states<sup>1,2</sup>. Therefore, any perturbation which affects the relative positions of these levels will also affect the quantum yield of fluorescence.

Previous work<sup>1-3</sup> indicates that the effect of perturbations, such as solvent effect, substitution effect and hydrogen bonding, on the quantum yield of fluorescence of an organic compound can be explained by considering the changes brought about in the relative positions of the lowest singlet and triplet states of the  $\pi\pi^*$  and the  $\eta\pi^*$  type. The same explanation has been extended to the present case.

The observed values for wave-numbers of the maximum of the longest wavelength absorption band ( $\bar{\nu}_a$ ) and the fluorescence band ( $\bar{\nu}_f$ ), and the relative quantum yield of fluorescence ( $Q_r$ ), of thionine in various solvents are shown in Table I.

TABLE I

Solvent	$\bar{\nu}_a$	$\bar{\nu}_f$	$Q_r$
Dioxane	13500	16440	0.67
Acetone	16560	16440	0.20
Water	16560	16340	0.18
Ethanol	16440	16340	0.23
Methanol	16440	16340	0.21
Butanol	16280	16120	0.23

From Table I we observe that the relative quantum yield of fluorescence,  $Q_r$ , of thionine decreases as the frequency of emission increases on going from one solvent to another.

It is known that in an organic molecule if the  $\pi\pi^*$  and the  $\eta\pi^*$  states lie close together, the molecule has a high probability of getting de-excited non-radiatively<sup>1,2</sup>. El-Sayed *et al.*<sup>4</sup> and Plotnikov<sup>1</sup> have shown that the rate of transfer of excitation energy from singlet  $\pi\pi^*$  to triplet  $\eta\pi^*$  and singlet  $\eta\pi^*$  to triplet  $\pi\pi^*$  is three to four orders of magnitude as compared to the rate of transfer of energy from the singlet  $\pi\pi^*$  to the triplet  $\pi\pi^*$  or the singlet  $\eta\pi^*$  to the triplet  $\eta\pi^*$ . The perturbation affects the energy of the

delocalised  $\pi\pi^*$  state more than that of the localised  $\eta\pi^*$  state.

In the case of thionine, the molecule being fluorescent,  $\pi\pi^*$  singlet is the lowest singlet state. Any perturbation, in the present case of the solvent effect, affects the energies of the excited states. An increase in  $\bar{\nu}_f$  indicates that due to perturbation the energies of the excited states are raised and the  $\pi\pi^*$  and  $\eta\pi^*$  states come closer because the  $\pi\pi^*$  state is affected more. This, in turn, enhances the interaction between  $\pi\pi^*$  and  $\eta\pi^*$  states, thus leading to a greater non-radiative deactivation of the excited molecule, and lesser quantum yield of fluorescence. This explains the results of present investigation on thionine where a decrease in  $Q_f$  is observed with an increase in  $\bar{\nu}_f$ .

The experimental results also indicate that the quantum yield of fluorescence of thionine in dioxane is very low. This is probably due to the appreciable superimposition of the absorption and fluorescence spectra in this case (as is obvious from Table I showing the two spectra lying very close). This would lead to greater non-radiative deactivation of the excited molecule due to higher chances of resonance transfer of energy and hence a smaller quantum yield of fluorescence.

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3. —, Machwe, M. K., Gopalakrishnan, K. and Murti, V. V. S., *Curr. Sci.*, 1972, 41, 326.
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#### DIPOLE MOMENTS OF SOME CHOLESTERYL ESTERS

THE molecules which form liquid crystals are generally lath-shaped and possess a sufficient number of groups of atoms which are either permanently dipolar or readily polarizable. The mesomorphic behaviour of lath-shaped compound depends on the relative strength of the terminal and lateral intermolecular attractions and their differences must be such that the melting occurs in stages. The balance between these terminal and lateral intermolecular attractions is of course very sensitive to change in chemical constitution and geometry of the molecule<sup>1</sup>.

The present paper reports the dipole moments of some cholesteryl esters (*viz.*, cholesteryl butyrate, caproate, heptylate, caprylate, pelargonate, decylate, laurate, myristate, palmitate, stearate and benzoate) in benzene solution at 45° C. The results are discussed in terms of molecular structure and are correlated with the cholesteric  $\rightarrow$  isotropic temperature.

Dipole moments are evaluated from the study of static or low frequency dielectric constant vs concentration of dilute solutions in nonpolar solvent (benzene). The experimental arrangement is the same as described by Chandra and Prakash<sup>2</sup>.

TABLE I  
*Dipole moments of some cholesteryl esters*

Cholesteryl ester	No. of carbon atoms in the terminal alkyl chain	Dipole moment (Debye)
Formate*	..	2.55
Acetate*	1	1.98
Propionate*	2	2.16
Butyrate	3	2.09
Caproate	5	1.86
Heptylate	6	1.78
Caprylate	7	1.79
Pelargonate	8	1.73
Decylate	9	1.74
Laurate	11	1.73
Palmitate	15	1.69
Stearate	17	1.62
Benzoate†	..	2.10

\* Ref. 3.

† This is not an alkyl chain.

The values of dipole moment are given in Table I. It also gives the dipole moment of a few more esters measured by Gopalakrishna *et al.*<sup>3</sup>. For smaller chain lengths it is observed that the dipole moment values alternate between odd and even number of carbon atoms in the alkyl chain. A similar behaviour is observed between the cholesteric  $\rightarrow$  isotropic transition temperature and the number of carbon atoms<sup>4</sup>. Temperature for transition from one phase to another phase of a mesomorphic substance depends upon the intermolecular forces (*e.g.*, dipole-dipole, dipole-quadrupole, etc.) and hence it is expected that dipole moment and transition temperature are somewhat correlated.

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