INVESTIGATIONS ON CONNECTIONS BETWEEN DECAY TIME OF FLUORESCENT SOLUTIONS AND OTHER FLUORESCENCE CHARACTERISTICS

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Solutions of some organic compounds solved in alcohol and water with and without glycerol resp. were studied in order to determine the connection between the decay time τ and other luminescence characteristics, such as quantum yield, degree of polarisation, and intensity of absorption. The decay time was measured with the phase fluorometer built by the author. Our results, more exact in principle than earlier data, enabled us to clear up some of the incertainties found in literature. It could be shown among others that τ as a function of concentration has no maximum, which is at variance with numerous earlier investigations. The cases in which the proportionality between decay time and yield holds have been established. New results were found concerning the dependence of the molecular volume on viscosity of the solvent, and the determination of the decay time from the intensity of absorption.

1. Introduction

The decay time τ of fluorescent solutions depends on numerous factors, for example on constitution [1], [2] and viscosity of the solvent, the latter influencing also the degree of polarisation [3], [4], as well as on temperature and concentration of the solution, this latter considerably affecting also the quantum yeld [5]. Furthermore the dependence of the decay time on layer thickness, caused by secondary luminescence [6], [7], [8], has to be mentioned.

According to theory, τ is closely connected with other luminescence characteristics. Among these, the connection with the luminescence yield was the first to be discovered and the most extensely investigated [5], [9]. According to LEVSHIN [5], in the case of quenching, this connection can be given as follows

$$\frac{\eta}{\eta_0} = \frac{\tau}{\tau_0}, \tag{1}$$

where τ and η refer to the quenched, τ_0 and η_0 to the unquenched fluorescence respectively.

The results of numerous earlier investigations upon the dependence of the decay time on concentration showed considerable deviations from this proportionality (*e. g.* [7], [10]) but also some disturbing effects were found (*e. g.* [7], [11]) which could be ascribed to secondary luminescence. The decay time as a function of concentration, obtained with the method elaborated by BUDÓ and SZALAY [8] in order to eliminate this disturbing effects, as well as the yield values are constant up to the region of concentration quenching.

It has been shown [12] that the relation (1) is valid only in the case of dynamic quenching, *i. e.* if there is no quenching due to inactive absorption by dimers present

at high concentrations. In this case quenching is static and the decay time constant and independent from changes of concentration, whereas the yield value decreases with concentration. Therefore it seemed justified to study concentration quenching in connection with decay time in detail for different dyestuff solutions.

The decay time is also closely connected with the degree of polarisation p of fluorescence. The quantitative relation between p and τ can be expressed by the well-known PERRIN—LEVSHIN-formula [4], [13].

JABŁOŃSKI and SZYMANOWSKI showed in their researches on polarised luminescence [14], [15], [16] that the decay time generally depends on the degree of polarisation of the solution and the angle ϑ enclosed by the electric vector of the partially polarised luminescence light observed and that of the linearly polarised exciting light.

The results of Jabłoński were experimentally controlled by several authors (*e. g.* SZYMANOWSKI [16] and KESSEL [17]), but only qualitative accordance was found. Recently BAUER [18] proved the validity of Jabłoński's theory with very exact fluorometric and polarisation measurements for uranin in different solvents.

With respect to our earlier results [19], [20], which proved the linear Perrin—Levshin-relation to be satisfactorily valid and the fundamental polarisation p_0 as well as the quotient v/τ to be independent of viscosity, our aim was to investigate the dependence of the molecular volume v on the viscosity of the solvent by measuring the decay time τ and the degree of polarisation p.

EINSTEIN's relation [21] between the natural lifetime τ_e and the intensity of absorption (or oscillator strength) holds mainly for resonance radiation or fluorescence processes with very narrow bands of emission and absorption, as shown by the investigations of LADENBURG [22], TOLMAN [23], LEWIS and KASHA [24]. Einstein's relation has been modified by STRICKLER and BERG [25] for substances with broader, less characteristic spectra such as solutions of complex organic dyestuffs; later on BIRKS and DYSON [26] made further refinements, thus obtaining a more exact relation.

FÖRSTER [12], supposing the validity of Blokhintsev's rule of mirror-symmetry, gives another formula for the relation between τ_e and the area below the absorption spectra, involving the intensity of absorption and the so-called mirror-frequency.

Among several further relations (see *e. g.* [27], [28]) we have to emphasize KETSKEMÉTY's modification [29] of NEPÓRENT's formula [30], (see also [31]), involving τ instead of τ_e, as well as the molar extinction coefficient $\varepsilon(\nu)$ and the fluorescence quantum spectrum $f_q(\nu)$ belonging to the frequency ν instead of the integrated absorption spectrum.

In the following we give the formulas mentioned above:

EINSTEIN's modified formula

$$\frac{1}{\tau_e} = \frac{8\pi\nu^2 n^2 \ln 10}{10^{-3} N c^2} \frac{g_i}{g_j} \int_0^\infty \varepsilon(\nu)\, d\nu, \tag{2}$$

where ν is the frequency belonging to the transition $j \to i$, n the refractive index of the solution, g_i and g_j the statistical weights of the lower and the higher (excited) states respectively, $\varepsilon(\nu)$ the decadic molar extinction coefficient and N Avogadro's number.

The expression of BIRKS and DYSON

$$\frac{1}{\tau_e} = \frac{8\pi \ln 10}{10^{-3} N c^2} \frac{n_f^3}{n_a} \frac{g_i}{g_j} \overline{\nu_f^3} \int \frac{\varepsilon(\nu)}{\nu}\, d\nu; \tag{3}$$

here n_f and n_a are the mean refractive indices of the solution over the fluorescence and absorption spectra respectively and

$$\overline{\nu_f^3} = \frac{\int f_q(\nu)d\nu}{\int f_q(\nu)\nu_f^{-3}d\nu},$$

where $f_q(\nu)$ means the normalised quantum spectrum of fluorescence as a function of the frequency ν. In the expression of STRICKLER and BERG [25], instead of n_f^3/n_a in (3) only a factor n^2 is found, for it is assumed that $n_f=n_a=n$, *i.e.* the solution has no optical dispersion.

FÖRSTER's formula

$$\frac{1}{\tau_e} = \frac{8\pi \ln 10}{10^{-3}Nc^2} n^2 \int \frac{(2\nu_0-\nu)^3}{\nu} \varepsilon(\nu)d\nu. \tag{4}$$

ν_0 denoting the mirror-frequency, that it is the frequency belonging to the point of intersection of the absorption and emission spectra of the same height.

KETSKEMÉTY's modification of NEPORENT's formula, wich holds for mirror-simmentry between the absorption and emission spectra,

$$\tau = \frac{c^2 N 10^{-3}\eta_0^2 f_q(\nu)e^{-h(\nu_0-\nu)/kT}}{8\pi n^2\nu^2\eta(\nu)\varepsilon(\nu)\ln 10}, \tag{5}$$

where $\eta(\nu)$ and η_0 are the absolute quantum yield of the fluorescent solution and its maximal value respectively, and $f_q(\nu)$ is the normalised fluorescence spectrum.

Earlier values of τ calculated with the above equations generally resulted to be less than those measured with fluorometric methods, the deviations surpassing the limits of error of the measurements. Besides errors of measurements and spectral factors, these deviations can be interpreted mainly as effects of secondary luminescence due to reabsorption of fluorescence. Namely the decay time observed will be apparently increased by the effect of secondary luminescence [8]. The true decay time τ corrected for secondary luminescence may result considerably less than the directly measured decay time τ'; with other words the fact that the calculated decay times are less than the measured values for must of the dyestuffs studied hitherto is to be attributed at least partly to the effect of secondary luminescence. Therefore we had to examine the measured decay times obtained in our experiments also from this point of view.

2. *Experimental methods and evaluation of results*

a) The phase fluorometer constructed by the authors and described in [32] is based esentially upon the same principle as the apparatus of BAUER and ROZWADOWSKI [33]. The range of measurements with our fluorometer is about 0,1 to 30 nsec, and the absolute error of measurement less than 0,07 nsec for decay times of $\approx$3 to 4 nsec most frequently observed in dyestuff solutions.

In order to check the correct working of our apparatus and to make the necessary corrections, various calibrating tests ewre made. We measured *e.g.* the degree of modulation of the modulating unit, the electron transit time of the photomultipliers as a function of the intensity and wavelength of exciting light and of fluorescence light, *etc.* [32].

b) Measurements of other luminescence characteristics were made with the following methods.

Absorption and emission spectra were measured with a recording spectrophotometer Optica (Milano) type CF 4 DR and the fluorometric attachment constructed for this purpose [34]. Emission spectra were corrected for reabsorption [12]; in this way, provided the necessary conditions given in [35] were fulfilled we obtained the true fluorescence spectra with very good approximation.

The absolute quantum yield was measured with the instrument constructed and described by DOMBI [36]; the true quantum yield was calculated from the observed yield with suitable corrections [35].

Table I

1	2	3	4	5	6
N°	Fluorescent compound	Concentration range (in mole/l)	Solvent	Additive agent	number of solutions studied
1	Fluorescein	$1\times10^{-6}-2\times10^{-2}$	H_2O	2.5×10^{-1} mole/l NaOH	14
2	Fluorescein	$1\times10^{-6}-5\times10^{-2}$	85%EtOH+15%H_2O	10^{-2} mole/l and 2.5×10^{-1} mole/l NaOH	12
3	Fluorescein	1×10^{-4}	0–96% glycerol+water	2.5×10^{-1} mole/l NaOH	9
4	Eosine	$2\times10^{-6}-2\times10^{-2}$	85%EtOH+15%H_2O	10^{-2}, 3×10^{-1} and 5×10^{-1} mole/l NaOH	15
5	Trypaflavine	$1\times10^{-5}-8\times10^{-2}$	85%EtOH+15%H_2O	2%CH_3COOH	10
6	Trypaflavine	2×10^{-4}	0–96% glycerol+water	2%CH_3COOH	10
7	Quinine sulphate	$1\times10^{-5}-1\times10^{-1}$	H_2O	In H_2SO_4	7

The degree of polarisation in viscous solutions was measured with our apparatus described in [37], and partly with its modification [38]. The true degree of polarisation was determined with the method given in [29] and [39] and partly also with our simpler method of correction described in [20].

The viscosity of solutions containing glycerol was measured with Höppler's viscosimeter, the density of the solutions with a picnometric method and the refractive index with Abbe's refractometer.

c) In our investigations upon decay time and other luminescence characteristics we used solutions of organic compounds (trypaflavine, eosine, fluorescein and quinine sulphate) of sufficiently high quantum yield and with absorption and emission spectra lying mainly in the visible range.

The dyestuffs of different provenience were subjected to careful and repeated chemical purification, until the extinction coefficient of the materials proved to be constant.

The compounds, solvents and additional agents used in our investigations and there respective ranges of concentration are given in Table I.

d) The true decay time τ was determined from the measured value τ using BUDÓ and SZALAY's [8] as well as our own method [32]. According to the first method

$$\tau = \tau'(1-\varkappa) \tag{6}$$

where $\varkappa$ is the quotient of the secondary and primary fluorescence sensed by the measuring device, defined by BUDÓ and KETSKEMÉTY in [35]. Using Eq. (6) and an expanded form of the expresion for $\varkappa$, we have given in [32] a simpler method for calculating the true decay time τ which leads to the following approximative formula:

$$\tau = \frac{l_2 l_3 \lg \frac{l_3}{l_2} + l_3 l_1 \lg \frac{l_1}{l_3} + l_1 l_2 \lg \frac{l_2}{l_1}}{\frac{1}{\tau_1'} l_2 l_3 \lg \frac{l_3}{l_2} + \frac{1}{\tau_2'} l_3 l_1 \lg \frac{l_1}{l_3} + \frac{1}{\tau_3'} l_1 l_2 \lg \frac{l_2}{l_1}} \tag{7}$$

where $\tau_i'(i=1, 2, 3)$ are the decay times measured with the corresponding layer thicknesses l_i.

3. *Investigations upon the dependence of decay time and quantum yield on concentration*

The connection between τ and η was studied for three dyestuffs (fluorescein, eosine and trypaflavine) in aqueous and alcoholic solutions. These measurements were made with exciting light of 436 nm wavelength; τ for quinine sulphate was measured with 365 nm exciting wavelength. The layer thicknesses of

the solutions of different concentration (10^{-3} cm—0,5 cm) were chosen with respect to the conditions of applicability of the method of correction for secondary luminescence (for details see [35]).

From our results, Table II shows the dependence on the molar concentration c_M of η_λ and τ measured in aqueous solutions of fluorescein, Table III the values of τ and τ/τ_0 for aqueous solutions of quinine sulphate containing sulfuric acid, with different concentrations and layer thicknesses. The subscript 0 denotes the true yields and decay times obtained with very low concentrations.

Table II

Fluorescein (H_2O, 1% NaOH)

1	2	3	4	5	6	7
N°	c_M (in mole/l)	η_λ	τ (nsec)		η/η_0	τ/τ_0
			calc. acc. to (6)	calc. acc. to (7)		
1.	1×10^{-6}	0.90	3.30	3.32	1.02	0.97
2.	2×10^{-6}	0.89	3.39	3.10	1.01	1.00
3.	5×10^{-6}	0.95	3.37	3.36	1.08	0.99
4.	1×10^{-5}	0.78	3.46	3.59	0.89	1.02
5.	2×10^{-5}	0.80	3.41	3.28	0.91	1.00
6.	5×10^{-5}	0.89	3.29	3.36	1.01	0.97
7.	1×10^{-4}	0.88	3.46	3.37	1.00	1.02
8.	2×10^{-4}	0.86	3.50	3.23	0.98	1.03
9.	5×10^{-4}	0.87	3.46	3.27	0.99	1.02
10.	1×10^{-3}	0.87	3.35	3.12	0.99	0.99
11.	2×10^{-3}	0.74	3.25	3.43	0.85	0.96
12.	5×10^{-3}	0.53	2.58	2.60	0.60	0.76
13.	1×10^{-2}	0.17	1.31	1.33	0.19	0.39
14.	2×10^{-2}	0.05	0.32	0.15	0.06	0.09

Table III

Decay time of quinine sulphate (1n H_2SO_4)

1	2	3	4	5	6	7	8	9	10
c_M (in mole/l)	l (in cm)							mean value	$\frac{\tau}{\tau_0}$
	0.001	0.005	0.01	0.02	0.05	0.1002	0.5001		
	τ (nsec)								
1×10^{-5}						19.76	18.90	19.33	1.00
1×10^{-4}				18.63		19.09	19.87	19.19	0.99
1×10^{-3}			18.29		18.69	19.06	18.47	18.62	0.96
3×10^{-3}		16.90						16.90	0.87
1×10^{-2}	16.42				14.53		14.41	15.12	0.78
5×10^{-2}	9.41							9.41	0.49
1×10^{-2}	6.59		5.91			6.63		6.37	0.33

The curves in Fig. 1 show the dependence on c_M of the quotients η/η_0 and τ/τ_0 for the five solutions studied.

Our investigations performed to check the connections between the true decay time τ and the quantum yield η led to the following results.

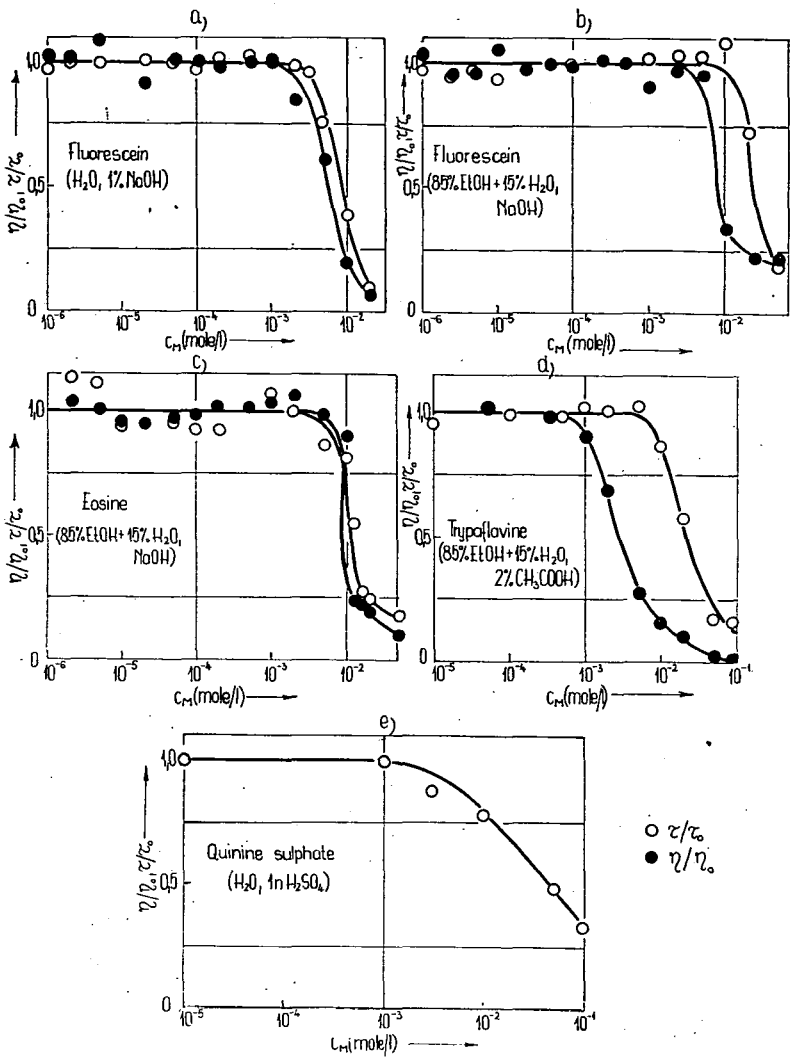

Fig. 1

a) The dependence of η on c_M found in our measurements with aqueous and alcoholic solutions of fluorescein and alcoholic solutions of eosine and trypaflavine confirmed the results of earlier investigations [40], [41].

b) Contrary to earlier results [7], [11], the curves $\tau = \tau(c_M)$ show no rise or maximum, but have a constant value up to the threshold concentration, like the initial portions of the curves $\eta = \eta(c_M)$.

c) The proportionality between $\tau(c_M)$ and $\eta(c_M)$ is approximately fulfilled for aqueous solutions of fluorescein and alcoholic solutions of eosine, in contradiction to results of some earlier investigations [6], [42].

d) This proportionality does not hold for alcoholic solutions of trypaflavine and fluorescein, in which τ/τ_0 begins to decrease at higher concentrations than η/η_0. The fact that no significant changes in absorption spectra were observed in the concentration range studied proves that there occurs no considerable dimerisation in the systems used. Accordingly the divergences from proportionality cannot be ascribed to static quenching produced by dimerisation but are probably due to the circumstance that the exponential law does not hold for the quenching at higher concentrations, as suggested by GALANIN [6], or to the occurence of initial quenching, discussed also by FÖRSTER [12]. Furthermore it may be supposed, according to VIEROSANU [43], that the „deformed" molecules behave like associated dimer molecules with respect to concentration quenching, the presence of both kind of molecules causing inactive absorption.

e) Our experimental results confirm the observation that the directly measured decay times of dyestuff solutions show considerable changes with the layer thickness as a consequence of secondary luminescence.

4. Investigations upon the decay time of viscous dyestuff solutions

In order to clear up the dependence of the molecular volume v on the viscosity of the solvent, we made measurements with aqueous solutions of fluorescein and alcoholic solutions of trypaflavine, both containing glycerol. In these solutions we measured the decay times $\tau^{\parallel}$, $\tau^{\perp}$ and τ_{55} of the components of luminescence light, oscillating in planes with $\vartheta = 0$, 90° and 55° respectively. These measurements were made with layer thicknesses of 0.1 and 0.25 cm for fluorescein, and 0.02, 0.05 and 0.1 cm for trypaflavine. The true decay times were calculated with Eq. (6) and with Eqs. (6) and (7) respectively. The values of τ obtained with both methods were in agreement within the limits of error.

The degree of polarisation for both solutions was measured with the layer thicknesses employed for the measurement of τ; the solutions, held at constant temperature of (30 ± 0.1 °C), were excited with the mercury line of 436 nm wavelength.

Table IV

1×10^{-4} mole/l fluorescein (glycerol + water, 1% NaOH)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
N°	Glycerol cont. (%)	$10^2 \times \eta_v$ (poise)	$1/\eta_v$ (1/poise)	p	$1/p$	r	$1/r$	$\tau^{\parallel}$	τ_{55}	$\tau^{\perp}$	τ (nsec)	$\tau^{\parallel}/\tau$	$\tau^{\perp}/\tau$
1	0	0.90	110.5	0.013	79.05	0.0085	118.08	3.09	3.50	3.27	3.21	0.961	1.019
2	15	1.47	68.0	0.023	43.76	0.015	65.15	3.25	3.48	3.49	3.41	0.954	1.024
3	30	2.68	37.3	0.056	17.72	0.038	26.08	3.21	3.54	3.57	3.44	0.934	1.037
4	45	5.11	19.5	0.097	10.29	0.067	14.94	3.14	3.17	3.44	3.33	0.944	1.034
5	50	6.60	15.1	0.114	8.75	0.079	12.63	3.11	3.17	3.44	3.31	0.940	1.039
6	65	16.50	6.06	0.186	5.38	0.132	7.56	2.95	3.26	3.36	3.19	0.924	1.055
7	75	36.92	2.70	0.269	3.71	0.197	5.07	2.62	3.13	3.41	3.04	0.859	1.121
8	85	107.58	0.92	0.356	2.81	0.269	3.72	2.60	3.03	3.46	3.02	0.861	1.146
9	96	386.29	0.25	0.426	2.35	0.331	3.02	2.66	2.92	3.22	2.86	0.929	1.124

Table IV contains the true degrees of polarisation p obtained from the measurements, the anisotropy of emission r, calculated with the formula $r = 2p/(3-p)$, and their inverse $1/p$ and $1/r$, the true decay times calculated from $\tau^{\parallel}$, $\tau^{\perp}$ and τ_{55} observed in the three directions of oscillation mentioned above, the value of τ calculated with JABŁOŃSKI's [44] equation

$$\tau = \tfrac{1}{3}\left[\tau^{\parallel}(1+2r)+2\tau^{\perp}(1-r)\right] \tag{8}$$

and the quotients $\tau^{\parallel}/\tau$ and $\tau^{\perp}/\tau$ for the aqueous solution of fluorescein containing glycerol.

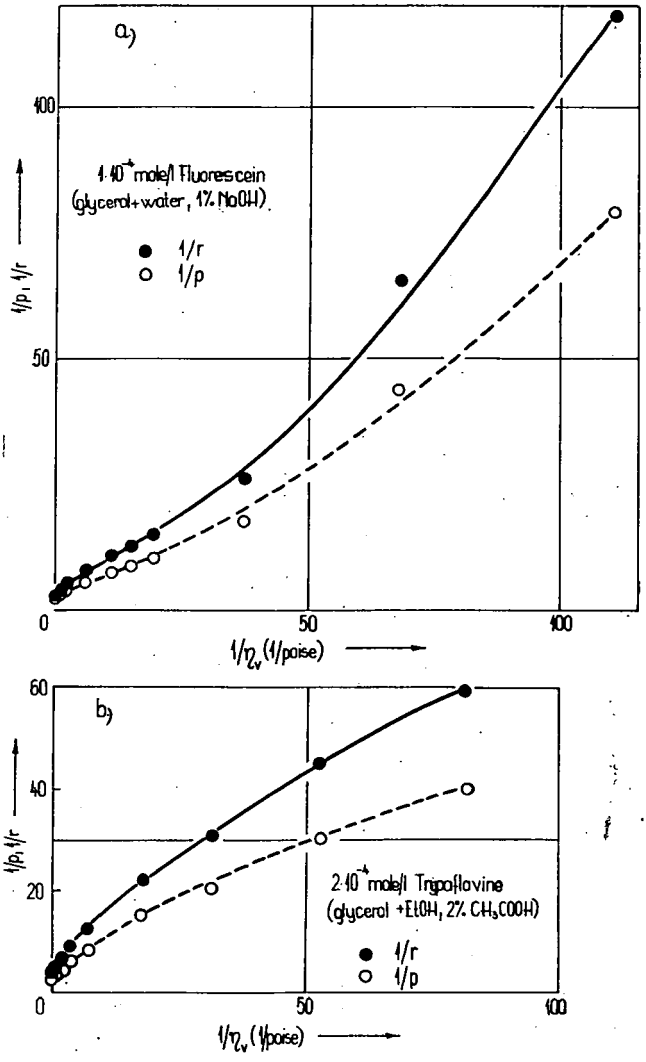

Fig. 2

Fig. 2 shows the values of $1/p$ and $1/r$ for both solutions as a function of $1/\eta_v$ as usual. The trend of deviation from linearity (Fig. 2a) is the same as observed by BAUER and SZCZUREK [45], though the measurements of these authors show greater deviations in consequence of their neglecting the effects of secondary luminescence. In the case of trypaflavine (Fig. 2b) we obtained curves concave from below for both $1/r$ and $1/p$ as a function of $1/\eta_v$, in accordance with measurements of SZALAY [19].

In Fig. 3 the fundamental emission anisotropy r_0, calculated with the method of JABŁOŃSKI [44], the molecular volume v, calculated with the Perrin—Levshin-relation from r_0 and the measured values of r, are given as function of the glycerol content expressed in per cent. The descending section of the curve r_0 for fluorescein solutions with low glycerol content, drawn with a broken line in Fig. 3a, cannot be

considered as reliable because of the errors of measurement. Apart from the section mentioned above, the shape of the curves r_0 and v is similar to those obtained by BAUER [18]. However, in our measurements we found the greatest change in v to be only of one and a half order of magnitude, against the changes of about three orders found by Bauer for both r_0 and v.

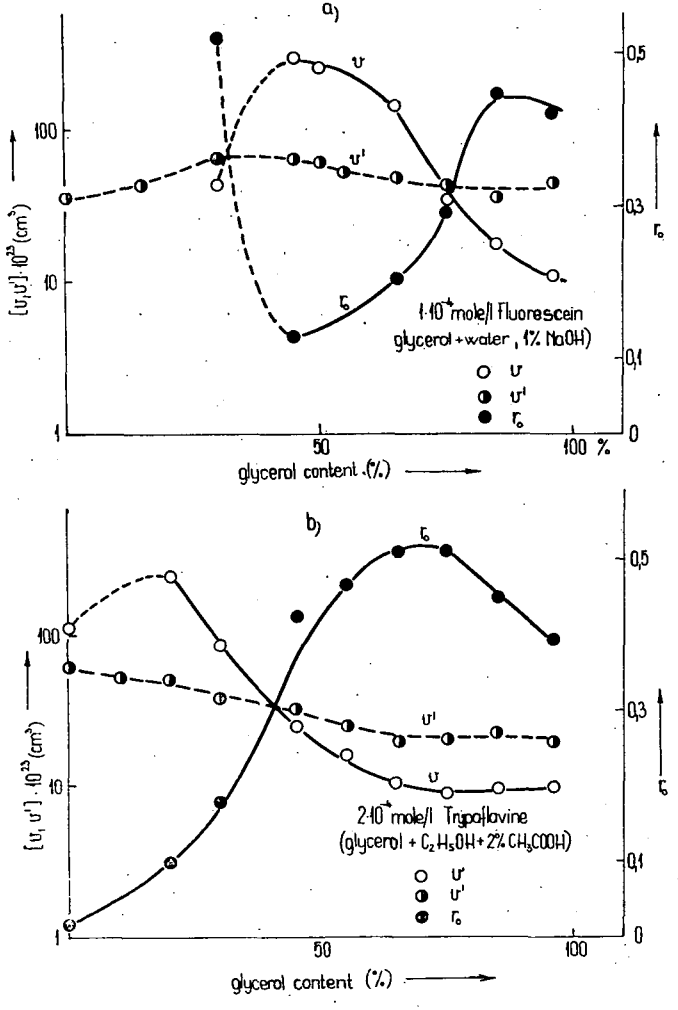

Fig. 3

The molecular volumes were also calculated by substituting the values of r_0 extrapolated for viscosity ∞ ($r_0 = 0.353$ for fluorescein and $r_0 = 0.345$ for trypaflavine) into the Perrin—Levshin-equation. The molecular volumes obtained in this way are shown by the curves marked with v' in Fig. 3. In the case of trypaflavine,

v' lies near to the molecular volumes calculated by SZALAY [19] with a similar method but supposing τ to be constant.

From our investigations on the decay time of polarised luminescence, it can be inferred that the molecular volume of the dyestuffs in solutions of different viscosity, using mixtures of water and glycerol, and of not dehydrated alcohol and glycerol respectively as solvents, increases with the decrease of the glycerol content, *i.e.* in the same direction as suggested by BAUER [18], however in a less extent. JABLOŃSKI and BAUER interpreted this increase with the great solvent capacity of water. Consequently, for our solutions the molecular volume will not be constant with changing τ and r_0, even if the Perrin—Levshin-relation is approximately fulfilled.

5 . Investigations upon the connection between τ and intensity of absorption

These calculations were made on the basis of the relations (3), (4) and (5), using the values of τ and η determined according to the above and the measured absorption and emission spectra.

Table V contains the measured values of τ_M corrected for secondary luminescence, τ_e and $\tau_{calc}(=\eta\tau_e)$, the absolute quantum yield η_λ measured with excitation at 436 nm wavelength, and the refractive index n_D of the solutions, as well as the mean values of the mirror wave numbers $\tilde{\nu}_0$ calculated with different methods. In the case of quinine sulphate τ_{calc} was calculated with the value $\eta_\lambda = 0.54$ taken from [46]. The values of τ_e and τ_{calc}, calculated with different methods, are to be found in columns 8 and 9 of the table in the following order: (F) calculated with Eq. (4), (S—B) with Eq. (3), and (N) with Eq. (5) respectively.

Our investigations led to the following conclusions.

a) The decay times $\tau_{calc}(=\eta\tau_e)$ calculated with FÖRSTER's formula (4) are in better agreement with our own measurements of τ_m (corrected for secondary luminescence) than with the results of earlier workers.

b) Calculations of τ_{calc} with the formulas of STRICKLER and BERG and BIRKS and DYSON respectively (3) are in very good agreement with our measurements for aqueous solutions of fluorescein in the case of not too high concentrations; an approximative accordance was found for fluorescein solutions containing glycerol, whereas solutions of trypaflavine with glycerol and of quinine sulphate showed significant divergences.

c) The values of τ_{calc} obtained with NEPORENT's modified relation (5), were in good agreement with our values of τ_m even in the case of solutions for which the relations mentioned under *a)* and *b)* did not prove valid.

d) For aqueous solutions of quinine sulphate, the results for τ_m calculated with all three relations differred considerably from our measured values. This can be ascribed to the circumstance that for quinine sulphate Blokhintsev's mirror-simmetry relation is not even approximately fulfilled.

It can be stated that the decay times obtained theoretically and the values determined from our measurements with a method more exact in principle than those used earlier are in good agreement in every case when this is to be expected

Table V

1	2	3	4	5	6	7		8	9	10	11
N°	Fluorescent compound; c_M (in mole/l)	Solvent; additive agent	η_λ	$\tilde{\nu}_0 \times 10^{-3}$ (cm^{-1})	$\bar{\tilde{\nu}}^3 \times 10^{-12}$ (cm^{-3})	n		(nsec) τ_e	(nsec) τ_{calc}	(nsec) τ_m	$\frac{\tau_{calc}}{\tau_m}$
1	Fluorescein 1×10^{-4}	water; 1% NaOH	0.88	19.96	6.881	1.3379	F	4.41	3.88		1.11
							S—B	4.06	3.57	3.50	1.02
							N	4.23	3.72		1.06
2	Fluorescein 1×10^{-4}	85% ethanol, 15% water; 1×10^{-2} mole/l NaOH	0.99	19.67	6.569	1.3662	F	4.27	4.23		1.23
							S—B	4.33	4.29	3.43	1.25
							N	3.34	3.31		0.97
3	Fluorescein 1×10^{-4}	96% glycerol; 1% NaOH	0.86	19.68	6.250	1.4678	F	3.77	3.24		1.11
							S—B	4.03	3.47	2.92	1.19
							N	2.53	2.18		0.75
4	Eosine 5×10^{-5}	85% ethanol, 15% water; 1×10^{-2} mole/l NaOH	0.76	18.81	5.681	1.3640	F	3.95	3.00		1.46
							S—B	4.18	3.18	2.06	1.54
							N	3.07	2.33		1.13
5	Trypaflavine 5×10^{-5}	85% ethanol, 15% water; 2% CH_3COOH	0.77	21.05	7.703	1.3605	F	3.64	2.80		0.84
							S—B	3.70	2.84	3.34	0.85
							N	3.96	3.05		0.91
6	Trypaflavine 1×10^{-4}	96% glycerol: 2% CH_3COOH	0.88	20.92	7.276	1.4699	F	3.43	3.02		0.83
							S—B	3.47	3.05	3.63	0.84
							N	4.44	3.91		1.08
7	Quinine sulphate 1×10^{-5}	water; 1n H_2SO_4	0.54	25.30	9.532	1.3387	F	10.17	5.49		0.28
							S—B	9.24	4.99	19.33	0.26
							N	9.33	5.05		0.26

by virtue of the shape and mutual position of the emission and absorption spectra. This result is to be considered as an experimental confirmation of the theories on the decay time.

* * *

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ИЗУЧЕНИЕ ВЗАИМОСВЯЗИ МЕЖДУ ВРЕМЕНИ ЗАТУХАНИЯ И ДРУГИМИ ХАРАКТЕРИСТИКАМИ ФЛУОРЕСЦЕНЦИИ

Л. Гати

Исследовалась взаимосвязь между длительностью флуоресценции τ и другими ее характеристиками, т. е. выходом, степенью поляризации, интенсивностью поглащения у некоторых органических соединений, растворенных в спирте, воде и глицерине.

Время затухания флуоресценции определялось авторами на сконструированном ими фазовом флуорометре.

Полученные результаты, которые теоретически точнее предыдущих, дали возможность выяснить им некоторые неопределенности литературных данных. Установили, что τ как функция концентрации, в отличии от многочисленных предыдущих исследований, не имеет максимума, и также в каких условиях выполняется пропорциональность между временем затухания и выходом люминесценции. Получили новые данные о взаимосвязи объема молекулы от функции вязкости растворителя, и также для определения времени естественного затухания из интенсивности поглащения.