The Behaviour of Gelatineous Dyestuffs in Rotating Magnetic Field

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Introduction.

The behaviour of dyestuffs in magnetic field has not been extensively investigated till now. Most of the results chiefly refer to crystal-phosphors. A de Hemptinne (1) expected the magnetic field to have an influence on extinction, but he could not point out any change. Later C. Gutton (2) found that the magnetic field — if it is not constant — increases the intensity of fluorescence emission. Gudden and Pohl (3) ascertained a quenching when excited dyestuffs were put into an electric field of very great intensity. This phenomenon was detailed and quantitatively investigated by F. Schmidt (4). Schmidt's results suggested to E. Rupp (5) to investigate the dyestuffs in a magnetic field of great field strength. E. Rupp found that the behaviour of dyestuff in magnetic field is similar to that in electric field.

Later Hinderer (6) investigated the effect of alternating electric field on fluorescence emission and recently similar investigations were carried out by G. Destriau (7). Destriau's researches showed that the originally unexcited dyestuff has an emission without an excitation in a very intensive alternating electric field.

All the researches up till now show that neither constant magnetic field nor constant electric field cause an influence on physical properties of dyestuffs. A Stark effect was not observed at all. A Zeeman effect was to be found on dyes which have a spectrum similar to line spectrum (8). I. Weiss could not observe a magnetic quenching of fluorescence emission even at field strength of about 60.000 gauss/cm. (9).

Fröhlich and Gombay (10) pointed out that a constant electric field of middling field strength does not influence the percentage of partially polarized phosphorescence emission. An effect of magnetic field on physical properties of gelatineous dyestuffs was not investigated at all.

From the researches up till now we can suppose that a constant magnetic field causes no changes in physical properties of dyestuffs, but a change in the state of magnetic field, effects a change in the structure of dyes.

In this paper we investigated the effect of rotating magnetic field on gelatineous dyestuffs.

Experimental Technique.

From a painted gelatine-plate of 0,1 mm thickness we made a circle-shaped disk having a diameter of 3,5 cm (11). The centre of the the disk was fitted to a fine Wollaston-wire. The circle shaped plate hung in a rotating magnetic field so that its plane was horizontal and it could be rotated round a vertical axis. The first experiments showed that the currents of air caused by the warming of measuring space when the magnetic field was switched on had so great an influence on

the swinging system that the measurements were not reproductive at all. Therefore we had to put the whole system into vacuum.

The arrangement of the apparatus is shown in Fig. 1. We removed the air from a glass vessel by means of a vacuum pump. The upper and the lower end of the vessel was closed with two glass plates. The vessel had an opening closed by stop-cock (B) to the pump. The air pressure was 2—3 Hgmm during the measurements measured by mercury manometer. The measurements were carried out by means of a mirror (T). Therefore the glass cylinder had a circle-shaped opening closed by a flat glass plate before the mirror, and we set a mm-scale in 1 m distance from the mirror in the usual manner.

The lower part of the vessel with the gelatine plate (A) was put into the rotating magnetic field. As after switching the current the temperature of the measuring space slowly rose we used an air cooling,

Fig. 1.

F : light source
L : lense
H : water cooler
P : prism
M : coils
A : gelatine plate
T : mirror

to the pump
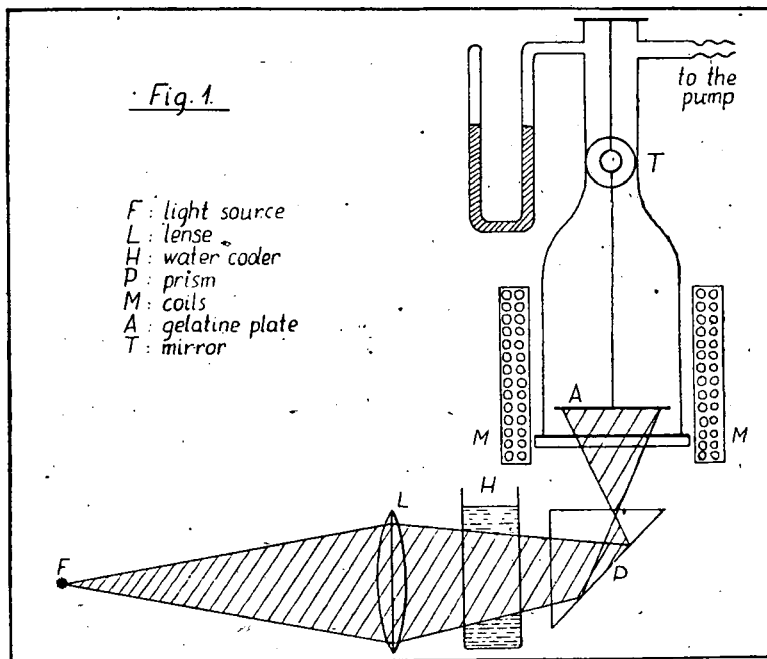
To know the influence of excitation we excited the plate (A) with an electric lamp of 1000 W (F). Light from F passes through a lense (L), and a prism (P), and a water cooler (H) to absorb the heat-rays.

On switching the magnetic field, the gelatine plate began to rotate. The turning away was about 15—20 mm on the scale. So the readings happened very easily. Immediately after switching the plate began to move very rapidly and the mirror was swinging. The amplitude of the swinging was 2—3 mm on the scale. While the mirror was swinging we took a mean value of the scale divisions. After 1—2 min when the swinging had ceased a direct reading was possible.

We investigated gelatine plates without any dye and also painted gelatine plates having different concentrations. The measurements refer to Rhodulin Orange N. To give the concentration we used a logarithmic one. —c concentration means 10^{-c} gr dye/cm^3 dry gelatine. All the measurements were taken at room temperature.

Results.

If we put the gelatine plate into a rotating magnetic field in the described manner it began to rotate. After some time the rotation ceased and the plate had a new resting point measured on the scale.

a) *The direction of the rotation of magnetic field.*

First of all we investigated the influence of direction of magnetic field rotation. The direction of rotating agrees with that of the hand of clock. The results referring to the different concentrations are shown in Table I. The time is given in minutes and the turning of the plate from its resting point is measured in scale divisions. The

Table I.

gelatine without any dye		c = − 1,00		c = − 1,75		c = − 2,25		c = − 3,00		c = − 3,50	
min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.
1	0,8	1	0,7	1	0,4	1	0,3	1	0,6	1	1,1
3	1,3	2	0,8	3	1,4	6	1,4	2	0,7	2	1,4
7	1,8	3	1,0	5	2,0	9	2,1	3	0,8	3	1,6
10	2,1	4	1,1	7	2,3	14	3,0	9	1,8	10	2,8
13	2,2	5	1,2	14	2,5	17	3,5	15	2,6	28	4,1
25	2,2	10	1,5	25	2,7	21	4,3	25	3,1	49	4,6
switching of the magnetic field		15	1,9	45	3,3	27	5,3	34	3,9	switching of the magnetic field	
1	1,9	20	2,1	55	3,2	34	6,4	64	4,6	1	4,1
4	1,3	25	2,3	switching of the field		49	8,6	70	4,7	7	3,4
7	1,0	30	2,5	2	2,8	66	10,4	switching of the field		14	2,9
12	0,8	48	2,6	5	2,0	79	12,4	6	4,3	32	1,4
		switching of the magnetic field		15	1,1	85	13,3	12	3,2	60	0,0
		1	2,2	30	0,2	110	13,5	18	2,0		
		4	1,9			switching of the field		25	1,6		
		8	1,3			1	10,5				
		19	0,2			9	8,0				
						15	5,4				
						40	0,3				

turning of the gelatine plate depends on the time which passes after the switching on of magnetic field. This dependence is shown in Fig. 2. where the time was measured on the horizontal axis in minutes and the turning of the plate on the vertical axis in scale divisions. As is to be seen, the unpainted gelatine plate had the

Fig. 2.

1. unpainted gelatine
2. c = −1·00
3. c = −1·75
4. c = −2·25
5. c = −3·50
6. c = −3·50
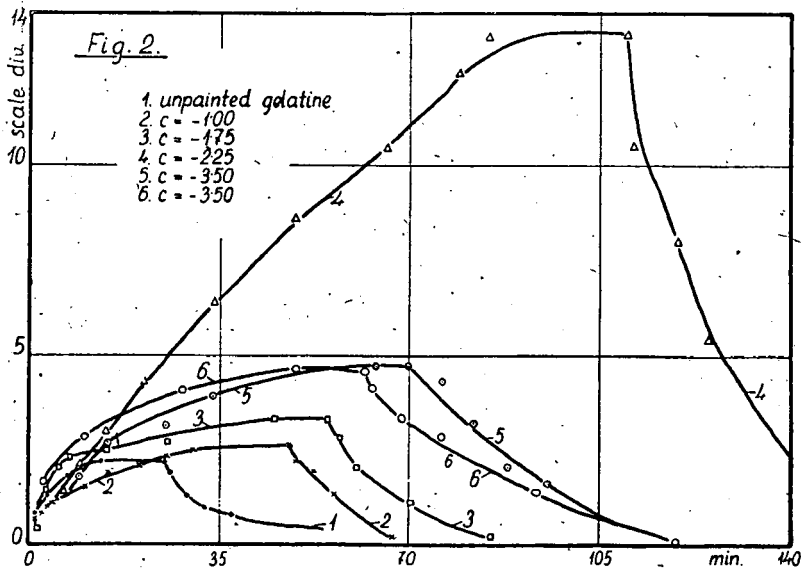
smallest turning in magnetic field. The rate of turning of painted plates was much greater. Fig. 2. shows that there is an optimal concentration from the point of view of maximal turning. This can be seen from the fact that, the curve belonging to concentration of —2,25 everywhere goes above the curves belonging to other concentrations. The time of reaching the maximum at plates of different concentrations depends also on concentration. If the maximum is greater then its reaching required more time.

Unpainted gelatine plate required 20 minutes and the painted one having a concentration of —2,25 required 100 minutes for reaching the maximum. Taking into account the fact that the swinging of the system ceased after 5 minutes when the swinging was caused by the turning of the torsion head, we have to suppose that the long duration of turning caused by magnetic field was effected by a change in the structure of the gelatine plate. This is a very important result because this peculiar behaviour of dyestuffs shows the existence of an interesting new magnetic effect which has never been observed before. Since the long duration of turning is in connection with the change of structure, the time of reaching maximum is evidently the duration of change of structure. As is to be seen the plates do not take their original resting point after the ceasing of magnetic field in 5 minutes as we could expect. There are concentration at which the reaching of the original resting point requires 40 minutes. This also supports the supposition of a change in structure of gelatine plate.

When the magnetic field rotates in the oposite direction (namely its rotation does not agree with that of the hand of a clock) then the behaviour of gelatine plates essentially alters compared to the former case. This is clearly shown in Fig. 3.

Above all we can see that, in the moment of switching on of the magnetic field, the direction of the rotation of field and that of the plate are the same, but after one minute the latter begins to rotate in the oposite direction. Consequently in this case the plates

Fig. 3.
1. unpainted gelatine
2. c = -1·00
3. c = -1·75
4. c = -2·25
5. c = -3·50
6. c = -3·50
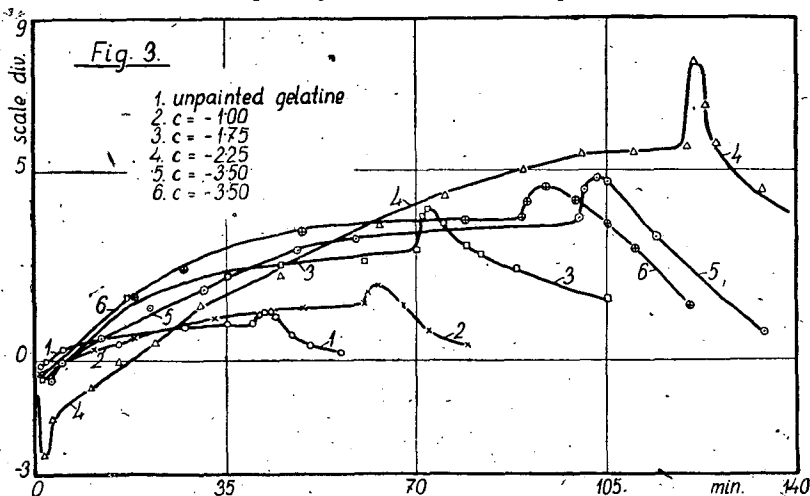
rotate only for a very short time in the same direction as the magnetic field, after this short time they rotate in the opposite direction and at last when the maximum is reached they take a new resting point.

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Comparing the rate of maximum in the two cases we see that it is higher at every concentration if the plates rotate in the same direction as the magnetic field. If we stop the magnetic field the plates do not turn back to their original resting point but are rotating for 5—6 minutes as if the magnetic field were still present. After 5—6 minutes the plates turn back and they tend to take their original resting point. The optimal concentration from the point of view of maximal turning is the same as it was in the former case. Fig. 3. was drawn
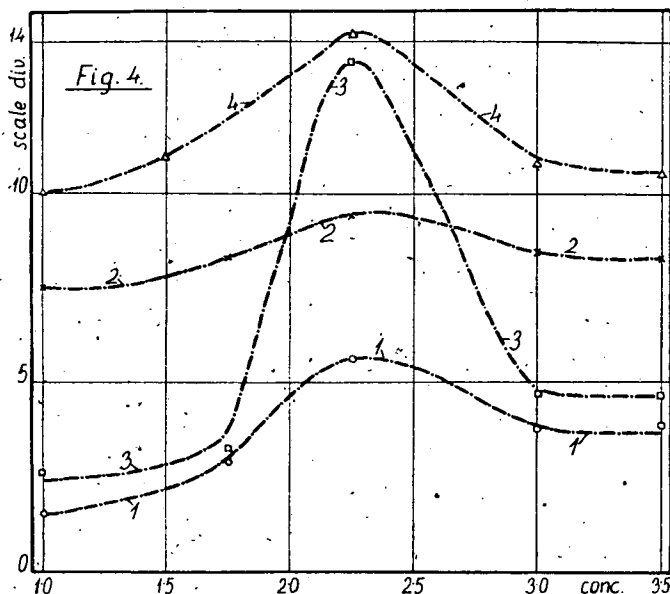
Table II.

unpainted gelatine		$c = -1,00$		$c = -1,75$		$c = -2,25$		$c = -3,00$		$c = -3,50$	
min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.	min.	scale div.
1	−0,1	1	−0,3	1	−0,3	1	−2,5	1	−0,4	1	−0,2
2	0,0	2	0,0	2	0,0	3	−1,5	2	−0,3	2	0,3
5	0,3	3	0,1	17	1,7	10	−0,7	4	−0,2	18	1,7
15	0,4	11	0,3	20	1,8	15	0,0	5	0,0	27	2,4
27	0,9	18	0,6	35	2,2	22	0,5	8	0,2	49	3,4
35	1,0	33	1,1	45	2,4	30	1,5	12	0,6	79	3,7
40	1,0	49	1,4	60	2,6	45	2,2	21	1,4	90	3,8
switching of the field		60	1,5	70	2,9	63	3,6	31	1,9	switching of field	
1	1,2	switching of field				75	4,3	42	2,5	1	4,2
2	1,3	1	1,8	1	3,8	90	5,0	48	2,9	2	4,4
3	1,3	2	1,9	2	4,0	100	5,4	59	3,2	3	4,5
4	1,2	3	2,0	5	3,6	110	5,5	100	3,8	4	4,6
7	0,7	4	1,9	9	3,3	120	5,6	switching of field		5	4,5
10	0,4	7	1,5	10	3,0	switching of field		1	4,5	8	4,3
16	0,2	12	0,8	11	3,0	1	7,9	2	4,6	10	4,2
		20	0,4	12	2,8	3'	6,7	3	4,8	15	3,5
				18	2,4	5	5,7	4	4,8	20	2,9
				35	1,6	14	4,5	5	4,7	30	1,4
						30	2,4	14	3,2		
						55	1,3	34	0,7		

from Table II.

Consequently we found on plates, investigated in rotating magnetic fiel having different direction of rotation, a very interesting phenomenon, namely that the direction of rotating of gelatine plates does not depend on the direction of rotating of magnetic field one minute after the switching on of magnetic field. The measurement happened in the following order: first we put the plate into the magnetic field in which its rotation agreed with that of the field and then we put it into the magnetic field rotation of which was opposite.

b) *The behaviour of excited plates.*

As we have described before we investigated the behaviour of excited gelatine plates in rotating magnetic field. The excitation was begun when the magnetic field was switched on. The behaviour of excited plates in rotating magnetic field is quite similar to that of the unexcited ones, the only difference between the two cases is that excited plates turn away in the magnetic field at a higher rate. As the phenomenon is just the same in the two cases we do not give detailed results. We give only the results which are necessary for comparing the behaviour of excited gelatine plates with that of the unexcited ones. This is to be seen in Fig. 4. The concentrations were

Fig. 4.

measured on the horizontal axis in logarithmic ones. The maximal tur-
ning from the ground resting point was measured on the vertical axis
in scale divisions. The results are found in Table III.

Table III.

concentration	turning in unexcited	opposite direc-tion excited	turning in unexcited	the same direc-tion excited
— 1,00	1,5	7,5	2,6	10,1
— 1,75	2,9	8,3	3,2	11,0
— 2,25	5,6	9,5	13,5	14,2
- 3,00	3,8	8,4	4,7	10,8
— 3,50	3,8	8,2	4,6	10,5

The 1. curve in Fig. 3. represents the concentration dependence
of maximal turning of the unexcited gelatine plate rotating in the same
direction as the magnetic field. The 3. curve shows the same depen-
dence but on excited plates. The 2. curve represents the concentration
dependence of maximal turning of the unexcited gelatine plate rotating
in the opposite direction as the magnetic field, and the 4. curve shows
that of the excited plate.

The excited plates do not turn back to their original resting point
after ceasing of magnetic field only when the excitation ceases too. There-
fore we had to take into account this circumstance so that we cor-
rigated the corresponding columns of Table III. substracting the tur-
ning caused by the excitation without magnetic field from that caused
by magnetic effect during excitation.

These results showed that the effect of magnetic field is greater
during excitation than in unexcited state. The optimal concentration is
the same in an excited and unexcited state.

Conclusions.

As the gelatine plate turning in rotating magnetic field reaches its
new resting point much later than if the same turning were caused by
means of the torsion head, it is quite sure that the magnetic field cau-

ses a change in the structure of gelatineous dyestuff. The peculiar behaviour which manifests itself in turning of the plate opposite the magnetic field is not to be explained from these investigations in an acceptable manner. Gombay (12) found a similar phenomenon in connection with his investigations referring to the electrical conductivity of gelatineous dyestuffs. Namely he detected that during an uniform raising of temperature a new electromotive force rises which causes a current flowing in a direction independent from the outer electromotive force. The analogy between Gombay's results and our investigations is not complete, but even so far is very surprising.

Undoubtedly the molecules of dyestuff play an important part in the existence of turning of plates which is to be seen from the concentration dependence of the turning.

The turning of the gelatine plate in rotating magnetic field can be explained in the following way. The molecules of dye are disordered without magnetic field. At the switching on of the magnetic field an electron shift is formed in a very short time and the molecules of dyestuff become polary. The magnetic field has an influence on the polary molecules, they come to an ordered state. This molecular arrangement causes the turning of the plate.

To give an exact and detailed explanation of change of structure caused by rotating magnetic field we have to stretch out the investigations.

Summary.

We investigated the behaviour of gelatineous dyestuffs (Rhodulin Orange N) in rotating magnetic field.

1. A painted gelatine plate hung in rotating magnetic field rotates, and takes a new resting point. At the moment of switching on of magnetic field the direction of rotation of plate and that of the magnetic field are the same. Later the direction of rotation of plate does not depend on the direction of rotation of magnetic field.

2. The rate of turning of plate depends on concentration of dyestuff. There is an optimal concentration of — 2,25.

3. The behaviour of excited and unexcited plates in rotating magnetic field is the same, but the rate of turning of excited plates is greater than that of the unexcited ones.

Szeged, Hungary August, 1948.

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Les Actions a Distance de R. d'Aubry de Puymorin.

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Le sujet de ce travail est un sommaire des actions à distance au point de vue de la physique atomique moderne.

Le chapitre premier précise les ideés attachées à l'électron. L'auteur définit le but de l'ouvrage en deux directions: *a)* Remplacer l'idée vectorielle du champ de force par celle du densité d'énergie pour tenir compte du fait que l'électron n'est pas une point charge, mais a un volume fini . *b)* Élaborer une énergétique laquelle est apte à traiter les phenomènes en connexion avec l'électron. Le sujet des deux chapitres suivants est cette énergétique generale. L'auteur suppose que toute énergie est énergie cinétique des atomes ou des particules élementaires. Il définit les systemes idéaux de tel façon que la definition renferme l'idée des champs.

Comme consequence il obtient la loi du changement de la force avec la vitesse que la Rélativité explique d'une autre point de vue: par l'augmentation de la masse avec la vitesse. L'autre consequence est la relation connue $\varepsilon = m^2$ mais par une expliquation cinétique et une relation entre la vitesse de propagation d'onde et celle des particules du milieu, vérifiée dans le cas des gaz monoatomiques.

Les deux derniers chapitres traitent les conséquences de cette énergétique en connexion avec les actions à distance. L'auter obtient deux actions entre les électrons: *a)* la répulsion Coulombienne, au coefficient $2/3$ et *b)* l'attraction Newtonienne mais sans le coefficient gravitant G. En supposant que la masse des électrons étant seule douée de propriété gravifique, il déduit une relation trés remarquable $G = {}^2/_9 (Nm)^2$ et donne au nobre Avogadro un sens profondi. Pour ce but il introduit une nouveaux systeme d'unités de mesures: systeme a 2 grandeurs fondamentales dans laquelle toute masse agissante (gravifique, électrique on magnéfique) a la dimension $L^3 T^{-2}$ et le G est un nombre pure, sans dimension.

La classification des forces termine cet ouvrage lequel est digne d'attention par ses hypotheses audacieuses et ses résultat remarquables.

R. Pauncz