INVESTIGATION ON THE INFLUENCE OF DIFFUSE REFLECTANCE OF LUMINESCENT GLASS POWDERS ON THE EMISSION SPECTRA

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It could be shown by reflectance and emission measurements on uranium glass powders that, taking into account reabsorption, the relative spectral energy distribution of luminescence is independent from the particle size and can be considered as identical with that of the bulk glass with good approximation.

Introduction

The question how and in what extent the reflectance and emission spectra of luminescent uranium glass powders depend on the dispersitivity was experimentally investigated. The inhomogeneity in powdered disperse systems causes scattering of the exciting light as well as of the luminescence. The character of the scattering depends on the conditions of illumination, on the degree of dispersity of the particles, on layer thickness, etc. [1—4]. Therefore the spreading and absorption of exciting light and luminescence depends on these parameters, too. Some of the changes in directly measured emission spectrum depending on the degree of dispersity could be interpreted by taking into account reabsorption.

Experimental method

The luminescent uranium glass (Schott filter glass GG 17) was ground in a ball and tube mill, then fractions of 200 μ, 125 μ, 90 μ, 20 μ, particle size were obtained by sieving with an appropriate set of sieves and by sedimentation in butyl-alcohol, respectively [5]. The true absorption of the bulk glass sample was determined in the usual way by measuring the transmission in comparison with air [6].

The diffuse reflectance spectra were measured with a spectrophotometer DFS-12 with an appropriate attachment. The influence of luminescent light on the results of measurements was eliminated by using monochromatic illumination and observation. The samples of different particle size were placed in a horizontal revolving sample holder containing four different fractions. The geometry of the attachment for reflectance measurement secured incidence under $\sim 45°$ and perpendicular observation. The bandwidth in the spectral range investigated was 0,5 nm. The scattered light was observed and introduced into the spectrophotometer by a light-pipe, the transmission of which was practically constant in the spectral region investigated. Absolute diffuse reflectance spectra of the uranium glass powder fractions were calculated with the data for reflectance of MgO published in [7]. The layer thickness of the sample was about 5 mm. The reflectance spectra obtained are to be seen in Fig. 1. Is to be noted that, according to our earlier investigations, the results of measurements with the usual Ulbricht-sphere and with SHIBATA's disposition were in accordance. Thus the measurements can be performed without restriction with the attachment described (corresponding to that of SHIBATA).

Luminescence spectra of uranium glass powders were measured both with a spectrophotometer Type DFS-12 provided with an emission attachment, and with our apparatus for emission measurements to be described below. In the first case the reflexion attachment described above was used as emission attachment. The exciting light of 436 mm was obtained by a monochromator Type SPM-1 from a low pressure mercury lamp Type PRK-2. Luminescent light was introduced into the spectrophotometer and observed as in case of reflectance measurements. Luminescence spectra were measured with a recording instrument Type EPP-09. In the instrument for emission measurements constructed by the authors a high-pressure mercury lamp Type HBO-200 with a monochromator Type SPM-2 was used for excitation. The sample holder containing six samples was in a vertical position, the samples being protected by a glass plate. The luminescence light of the samples impinged on the sensing monochromator through a lens and was registrated photoelectrically.

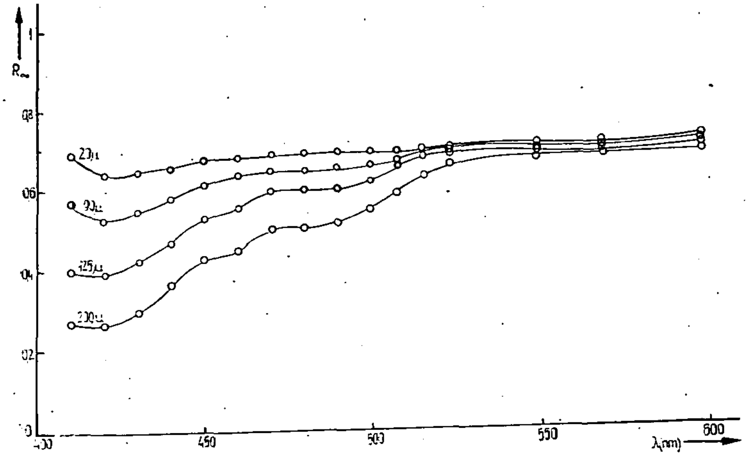

Fig. 1

Results of measurements

Typical colour curves (nearly proportional to absorption spectra) of powder fractions of different particle size, calculated with KUBELKA—MUNK's theory [8], are shown in Fig. 2. Both the diffuse reflectance spectra and absorption spectra exhibit a marked dependence on particle size. With decreasing particle size the structure of the spectra becomes less marked and the reflectance shows a definite increase in the short wavelengths region, whereas in the long wavelength region, where the absorption approaches zero, the scattering is nearly the same, for different particle sizes and independent from wavelength. In Fig. 3 the true absorption spectrum of the bulk glass used is also plotted. Comparison with the absorption spectra calculated from reflectance measurements shows that in case of powders the structure of the spectra is less distinct as a consequence of scattering, though the wavelengths of the maxima and minima are identical.

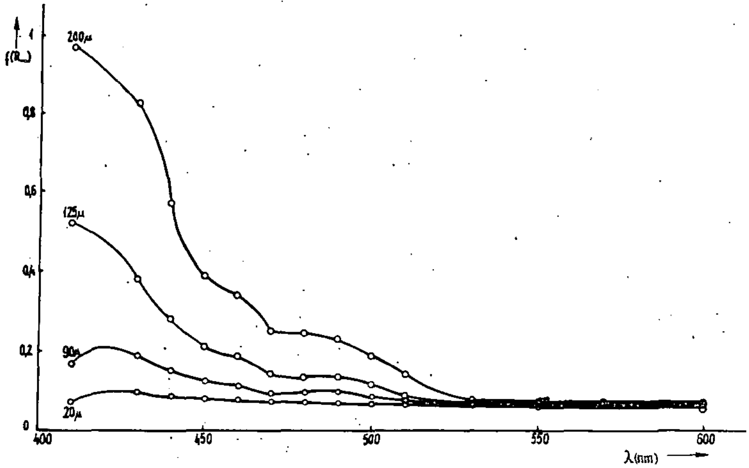

Fig. 2

Normalized luminescent spectra of powder fractions of different particle size as well as of bulk glass, corrected for sensitivity of the apparatus are presented in Fig. 4a, 4b, 4c, 4d. Both arrangements described above gave identical results.

In Fig. 5 the relative luminescence intensities compared with the intensity for 200 μ particle size are given as a function of the particle size. As can be seen, the intensity of luminescence strongly depends on the particle size, it decreases with decreasing size of the particles. This is in accordance with the results obtained in [1], but contradicts the findings of [4]. From the formula of D. OELKRUG and G. KORTÜM [9] to determine the true luminescence spectra, taking into consideration

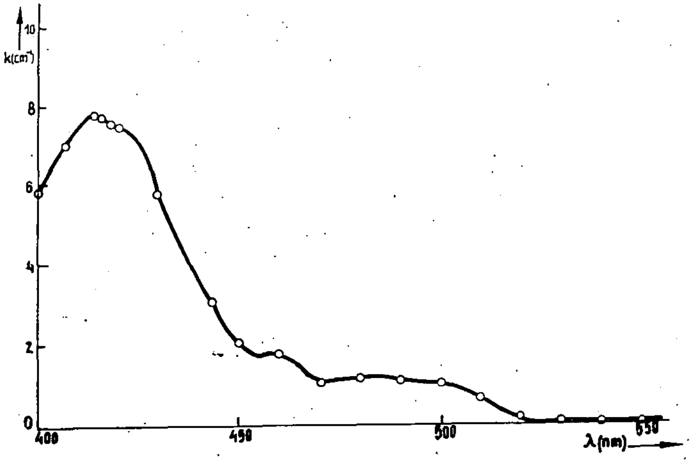

Fig. 3

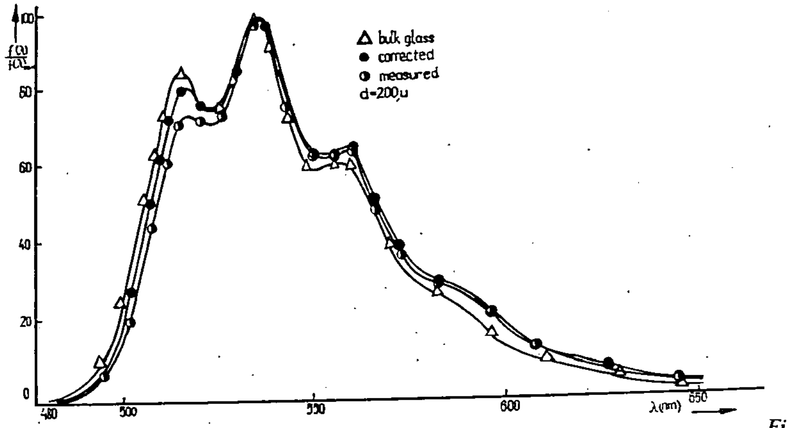

Fig. 4a

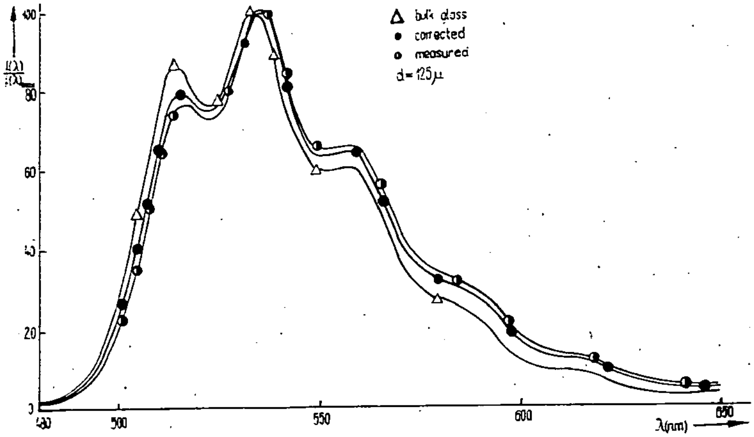

Fig. 4b

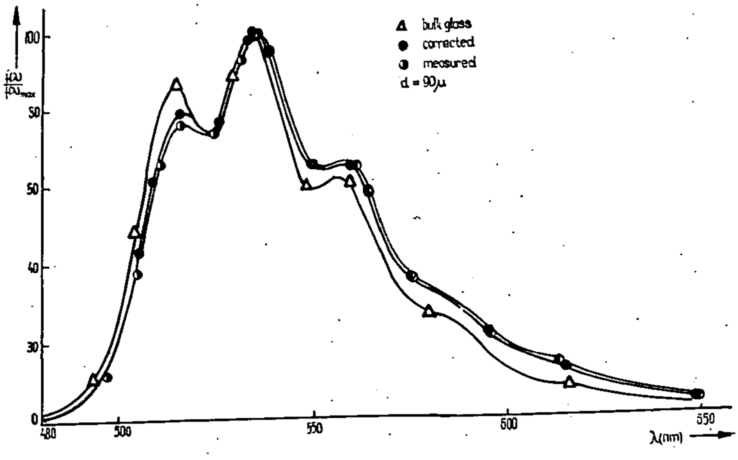

Fig. 4c

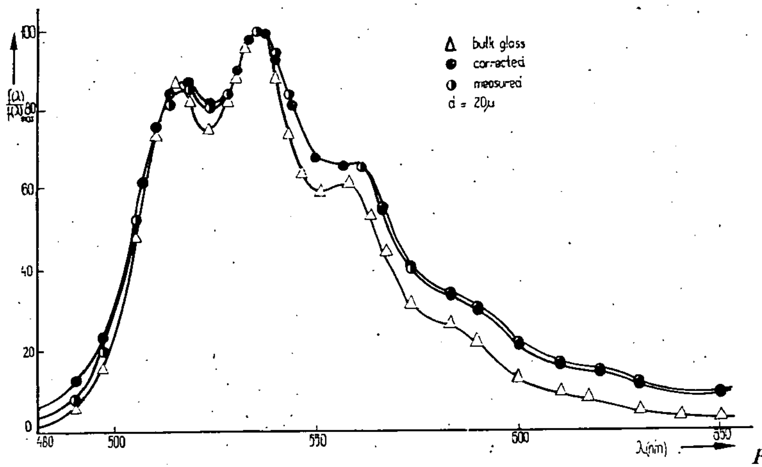

Fig. 4d

reabsorption, the normalized luminescence spectrum corrected for reabsorption has been calculated as follows:

$$\frac{f(\lambda)}{f(\lambda')_{\max}} = \frac{f'(\lambda)}{f'(\lambda')_{\max}} \frac{A(R_{\infty A}, R_{\infty E})}{A(R_{\infty A}, R_{\infty E})_{\max}}.$$

Here $f'(\lambda)$ is the intensity of luminescence measured at wavelength λ, $f'(\lambda')_{\max}$ the intensity of luminescence measured at the wavelength λ', which gives the maximum luminescence intensity, and

$$A(R_{\infty A}, R_{\infty E}) = \frac{\dfrac{1-R^2_{\infty A}}{R_{\infty A}} + \dfrac{1-R^2_{\infty E}}{R_{\infty E}}}{1+R_{\infty E}},$$

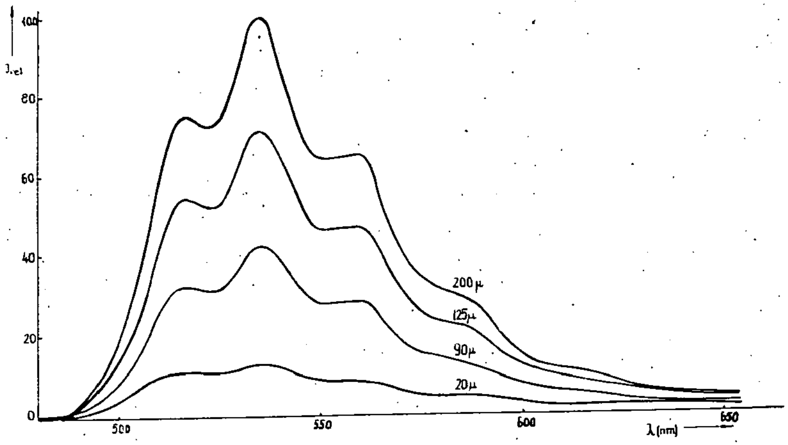

Fig. 5

where $R_{\infty A}$, $R_{\infty E}$ mean the absolut reflectance measured at the wavelength of the exciting light and of the emission, respectively. In Fig. 4a, 4b, 4c, 4d the values of $f'(\lambda)/f'(\lambda')_{\max}$ calculated with the above formula are also shown as functions of λ for powder fractions of different particle sizes. It can be seen that the spectra corrected for reabsorption on the basis of [9] give a better approximation of the true emission spectrum of powdered luminescent materials; the spectral energy distribution is almost independent from particle size.

Further experimental and theoretical work on this problem is going on.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ДИФФУЗНОГО ОТРАЖЕНИЯ НА СПЕКТРЫ ЛЮМИНЕСЦЕНЦИИ ЛЮМИНЕСЦИРУЮЩИХ СТЕКЛЯННЫХ ПОРОШКОВ

Б. Карвай, Ф. Пинтер и Л. Сёллёши

На основе измерения спектров отражения и люминесценции у порошков уранилового стекла было показано, что с учётом реабсорпции относительное спектральное энергетическое распределение люминесценции не зависит от размера порошков и хорошо приближается к относительному спектральному энергетическому распределению люминесценции массивного стекла.