Spectral Sensitization of Microcrystals a Core-Shell with the Inner Centers of a Photosensitivity

Boris Sechkarev, Larisa Sotnikova, Marina Ryabova, Tanya Ignatieva, Alex Utechin
Kemerovo State University, Kemerovo, Russia

Abstract

The heterocontact systems are in focus of attention of the researchers all over the world, since their use gives ample opportunities of management of photoprocess at a microlevel.

It was investigated the influence of a spectral sensitization of an shell by polymethine dyes with maxims of absorption in the field of 420 - 570 nm on a inner photosensitivity, maximal optical density of the developed inner image and optical density of a inner fog for microcrystals AgBr(I)/AgBr, AgBr/AgBr.

It was shown that the inner centers of a photosensitivity most effectively sensitize by dyes, the maximum of which absorption correlates with width of the forbidden gap of core microcrystals.

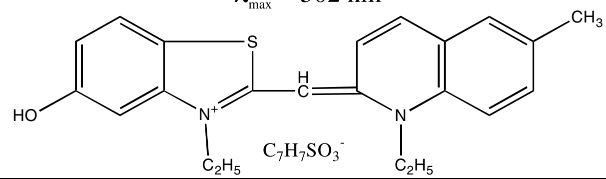
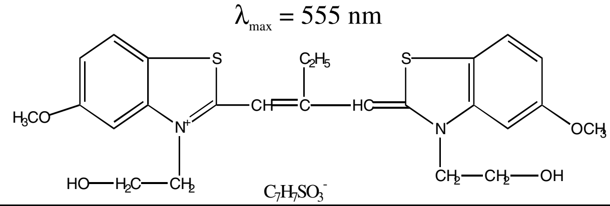
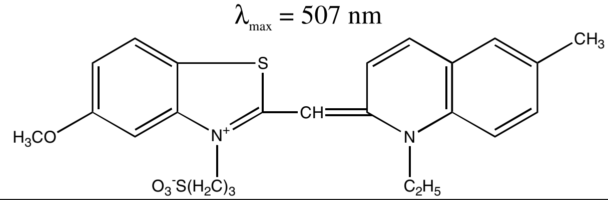
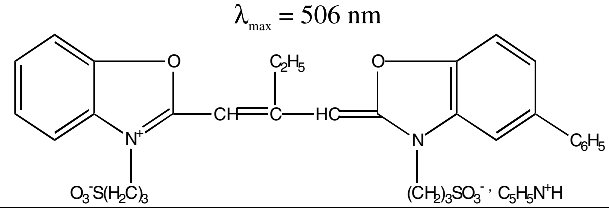
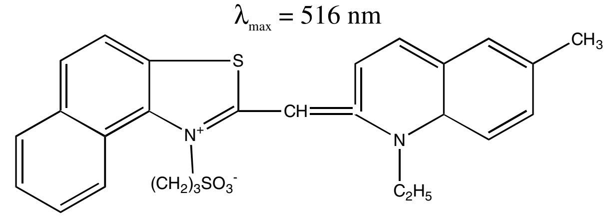
Introduction

The inner latent image centers in heterocontact core-shell microcrystals reveal the increased stability[1]. Unfortunately the reception of the inner latent image with a satisfactory level of optical density of darkness is impossible without a spectral sensitization. By using an optical sensitization it is possible to increase low optical density of the inner image[2]. However the spectral sensitization of a core crystals and subsequent growing of shell results in desorption of dyes from a surface of core microcrystals. The purpose of the present paper was revealing the conditions of a spectral sensitization of the inner centers of a photosensitivity by adsorption of dyes - spectral sensitizers on a surface of core-shell microcrystals.

Results and discussion

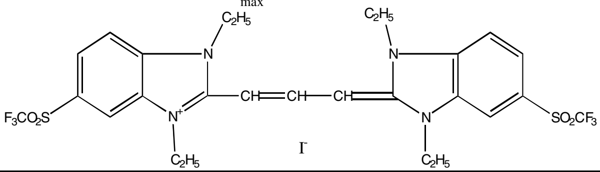
For investigation of laws of the optical sensitization of a core-shell microcrystal the dyes having maximal band of absorption of alcohol solutions from 460 up to 580 nm were chosen. The structural formulas of the investigated dyes are given in Table 1.

Table 1.

Spectral sensitization
Dye 1 λ_{max} = 502 nm 
Dye 2 λ_{max} = 555 nm 
Dye 3 λ_{max} = 507 nm 
Dye 4 λ_{max} = 506 nm 
Dye 5 λ_{max} = 516 nm 

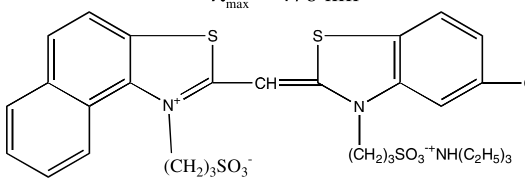
Dye 6

λ_{max} = 520 nm



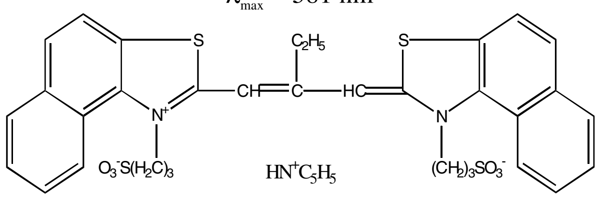
Dye 7

λ_{max} = 476 nm



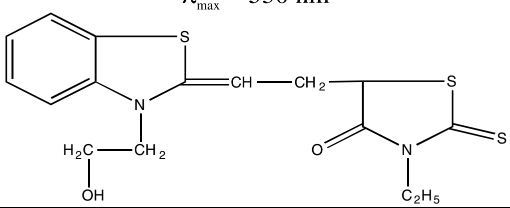
Dye 8

λ_{max} = 581 nm



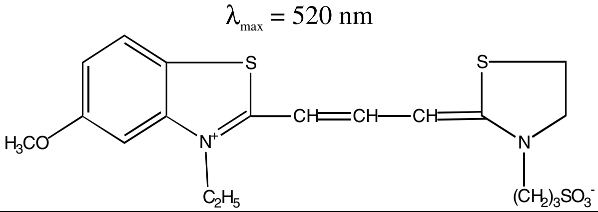
Dye 9

λ_{max} = 530 nm



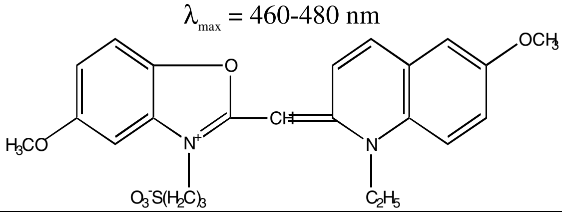
Dye 10

λ_{max} = 520 nm



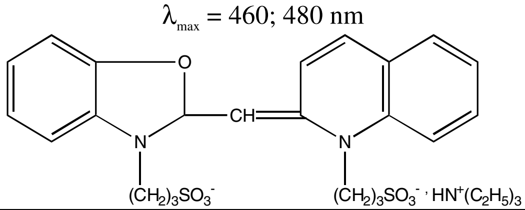
Dye 11

λ_{max} = 460-480 nm



Dye 12

λ_{max} = 460; 480 nm



For realization of experiments on a spectral sensitization of the inner centers of a photosensitivity the core emulsions containing cubic AgBr and $AgBr_{0,97}I_{0,03}$ microcrystals with 0,3 microns average equivalent diameter and factor of a variation on the sizes 12 % were used. The core emulsions were subjected to a sulfur-plus-gold chemical sensitization up to optimum sensitometric parameters, stabilized by 1-phenil-5-mercapto-1,2,3,4-tetrazolium and grew by an AgBr shell with thickness of 35 nm. The thickness of the shell was determined by a calculation way on the base of amount of AgBr was grew on the core. The average equivalent diameter of a core microcrystal, necessary for account, was determined on electronic microphotos of coal replicas of microcrystals. The dyes was adsorbed on shell of microcrystal in concentration of 9,3-18,6 10^{-8} mol/g Ag

The preliminary researches on core emulsions have shown that the chosen dyes from point of view of sensitizing action on a chemically sensitized core emulsion can be related to three groups:

1. The poorly influencing on the initial sensitometric characteristic of a core emulsion in the investigated interval of concentration of dye (dyes 1, 2, 3, 4, 5 and 10);
2. The lowering an initial level of photosensitivity of a core emulsion, especially, with increase of concentration of dye (dyes 6, 7);
3. The raising the photosensitivity level of a chemically sensitized core emulsion with increase of concentration of dye (dyes 8, 9).

At surface development of the received core-shell microcrystals the image of an optical wedge completely was absent. The inner development allows to find out the image of an optical wedge having maximal optical density of a darkness in 3 times lower than initial level D_{max} of a core emulsion before growing of a shell.

The maximal concentration of dye from the interval investigated on a core emulsion ($9,3*10^{-8}$ mol/g Ag) was used. In this case of surface latent image the using of high concentration of spectral sensitizers is limited because of a formation of j-aggregation of dyes, which consequence is the destruction of the surface image centers by photoholes. However for core-shell microcrystals with the inner sensitivity centers it is possible to apply dyes in higher concentration than usually. Therefore for some experiments the double concentration of dyes ($1,9*10^{-7}$ mol/g Ag) were used. The resulting sensitized samples of core-shell emulsions were developed in a surface and inner developer.

The sample of an core-shell $AgBr_{0,97}I_{0,03}$/AgBr emulsion without dye adsorption has the weak photoresponse at surface development in the field of high expositions. The adsorption on the shell of dyes 3, 5, 7 results in increase of maximal optical density with simultaneous increase of a photosensitivity at surface development. This circumstance specifies formation of the surface development centers. The adsorption of other dyes does not influence on the sensitometric characteristics of an core-shell emulsion.

The inner development of samples shows dependence of maximal optical density of a darkness on presence of adsorbed dye on the shell. The core $AgBr_{0,97}I_{0,03}$ emulsion before shell growing has D_{max} = 3,0 and after shell formation deep development gives D_{max} = 1,0. The adsorption of dyes 4, 6, 9 on the shell allows to increase D_{max} up to a level of a core emulsion. However in the case of dye No.4 it is possible to explain the increase of maximal optical density of darkness by the contribution of the surface development centers. The dyes 6 and 9 as optical sensitizers in relation to a core emulsion have different properties. The dye No.6 reduces a photosensitivity a little influencing on D_{max}. The dye 9 raises a photosensitivity in 3 times, thus in 2 times reducing D_{max}. Therefore it is impossible to explain increase deep D_{max} at an adsorption of dyes 6 and 9 by a traditional way.

We consider that for reception high inner D_{max} it is necessary to adsorb on a surface of a shell the dye with a long wave absorption band (quantum energy equal to energy of the forbidden zone of a silver halide of a core). For the confirmation of this assumption the experiment was carried out on core-shell system AgBr/AgBr. In this case it was necessary to expect increase inner D_{max} at an adsorption on the shell of dye with light absorption maximum at 460 nm that corresponds on forbidden gap of AgBr. The surface development core-shell AgBr/AgBr microcrystal doesn't give any density of darkness even at the maximal exposition. It was found that inner development gives the highest D_{max} in a case of adsorption on a shell of the dye 12 with λ_{max} = 460 nm.

As a result of the carried out experiments it was established that there is an interrelation between energy of light, absorbed by dye and width of the forbidden zone of a silver halide of core. It gives the additional practical recommendations to for selection of dyes for reception of the inner image in heterocontact core-shell systems.

References

1. Berg W.E., Frei E.A. *Proc. ICPS, Moscow, 1970*
2. Sechkarev B.A., Sotnikova L.V., Ryabova M.I. *Proc. ICPS*, 1998., Antwerp, Belgium. V1, pg. 486.