Spectral and spatial light absorption by chromophores (skin and phantom)

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1. INTRODUCTION

For research of photochemical processes which take place under the influence of light with definite wavelength it is important to know what quantity of light was absorbed by some or other chromophor. In photochemotherapy this gives an opportunity to choose the power, time and wavelength of light for effective influence. It is perfectly clear that the direct measurements of these contributions to absorption is difficult. So, it is necessary to use the numerical methods with application of effective models of light transport inside the sample. The purpose of the work is to develop the calculation method for partial contribution of separate chromophores based on 5-layer skin model.

2. THEORY AND EXPERIMENT

On the basis of the diffusion approach of light transport theory[1] has been developed the program allowing to calculate the light distribution inside the sample and partial contribution of separate skin chromophores. In the program the difference of spectral properties of layers of the sample under investigation is taken into account . The applicability limits of the theory was tested on experimental phantom which is a mixture of milk with isotonic solution of NaCl.[2] The sample was subjected to linearly polarised light with wavelength 420-500 nm. The method of determining the optical characteristics corresponded to ones proposed . The measurements in polarised light corresponded to the light transport without scattering, whereas the measurements in non-polarised light implied the light transport with scattering.

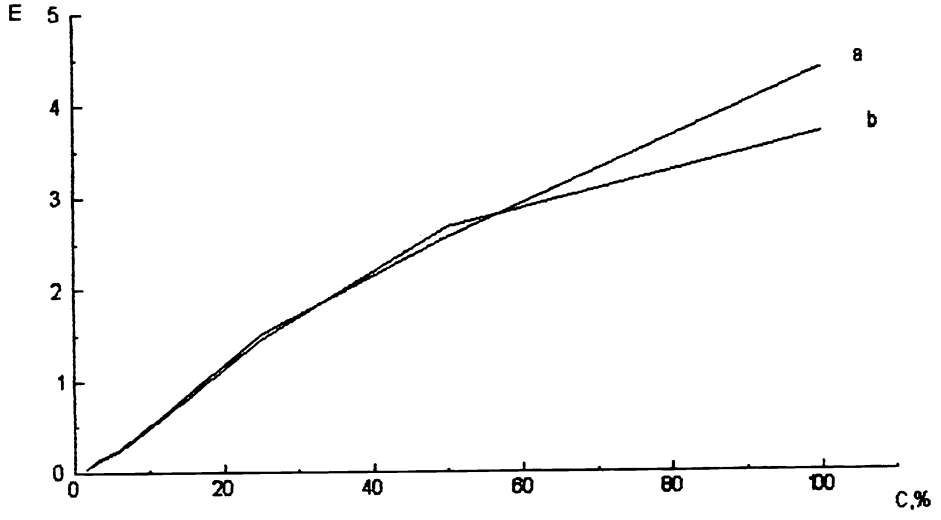

Fig.1. Extinction for mixture of milk with isotonic solution NaCl at different concentrations of milk (experiment) . a-thin cavity, b-thick cavity

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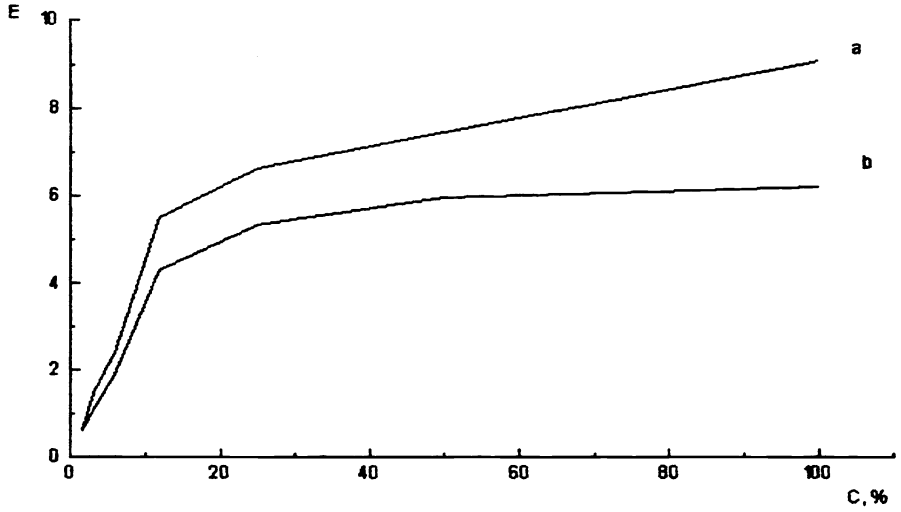

Fig.2. Extinction for mixture of milk with isotonic solution NaCl at different concentrations of milk (experiment) . a-thin cavity, b-thick cavity

From obtained by the authors data (Fig 1,2) it is clear that with increasing the milk concentration the multiple scattering replaces the single scattering and the possibility arises to use the diffusion approach of the light transfer theory. For a thin cavity this occurs at the concentration of milk 100%, for a thick cavity - at 25%. Obtained in the data processing parameters (scattering coefficients μ_s) are presented in Table 1. The table data show too that in the thick cavity takes place the multiple scattering at 25% concentration of milk.

Table 1
Scattering coefficients of mixture of milk with isotonic solution NaCl at different concentrations of milk and cavity thickness

C, %	1.5	3	6	12	25	50	100
μ_s,cm^{-1} (d=0.01cm)	-	13.72	-	64.14	152.05	256.97	440.17
μ_s,cm^{-1} (d=0.1cm)	6.38	14.75	27.08	62.98	66.12	74.34	90.97

By the solution of reverse problem with the using of the data of Table 1 we obtained curves presented in Fig 3,4. From them it follows that the diffusion approach may be also used for the thick cavity starting from 25% concentration of milk. For the thin cavity (thickness 100 μm) the diffusion approach does non apply. This confirms the absence of the multiple scattering in phantom with thin cavity. The calculated extinction coefficients E= -ln(I/Io) are presented in Table 2. The differences in data are explained by the distinctions of the geometry conditions of the experiment and theory.

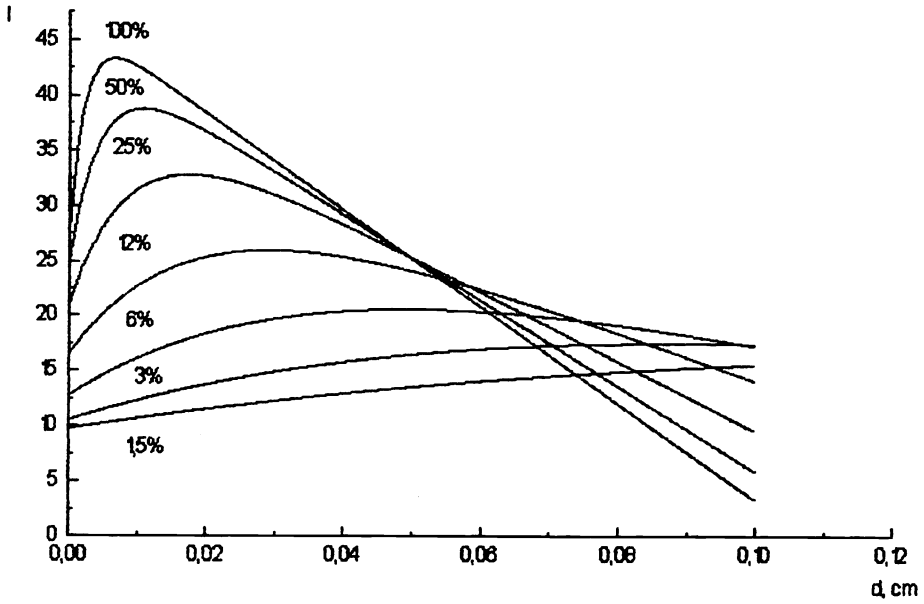

Fig.3. Calculated light intensity distributions in the mixture of milk with isotonic solution NaCl at different concentrations of milk depending on the depth in the sample. (thick cavity)

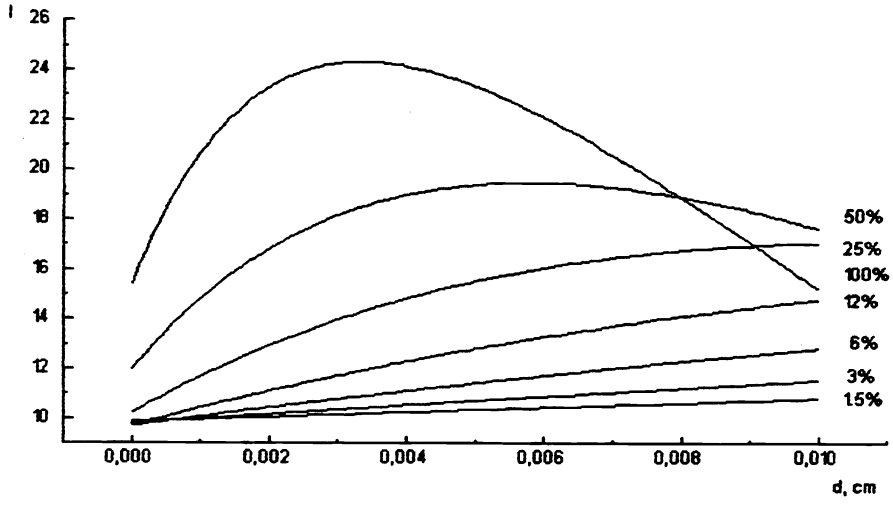

Fig.4. Calculated light intensity distributions in the mixture of milk with isotonic solution NaCl at different concentrations of milk depending on the depth in the sample . (thin cavity)

Table 2

Calculated extinction coefficients of mixture of milk with isotonic solution NaCl at different concentrations of milk and cavity thickness

C, %	1.5	3	6	12	25	50	100
E, (d=0.01cm)	-0.076	-0.142	-0.248	-0.39	-0.53	-0.567	-0.417
E, (d=0.1cm)	-0.44	-0.554	-0.54	-0.34	0.043	0.528	1.095

Never the less , the qualitative behaviour of calculated curves is in agreement with that of the experimental curves. This allows to conclude that the diffusion approach is suitable to such experimental phantoms.

As the preliminary results we calculated the partial contribution of blood absorption for conventional 5-layer skin model[3] (Fig.5) The parameters of skin are presented in table 3. The calculated absorption is 9.64 W/cm^2 for skin and ≈0.45 W/cm^2 for blood, such that absorption in dermis with pexus superficalis 0.45 W/cm^2 , in dermis with plexus profundus 5.71 10^{-5} W/cm^3 .

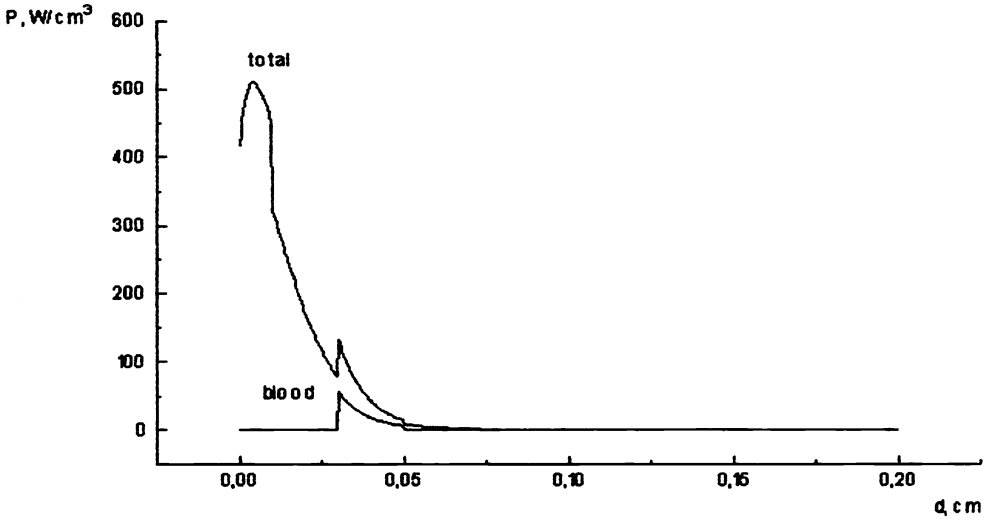

Fig.5. Calculated power density of light absorbed by skin (total) and blood of skin (blood) depending on the depth in the sample

For following research and determination of partial contributions of skin chromophores to absorption it is necessary to have information about absorption and scattering coefficients, locations and concentrations of these chromophores.

3. REFERENCES

1. Scott A. Prahl. "Light transport in tissue ", Dissertation, The university of Texas., 1988.
2. A.B.Pravdin, V.I.Kochubey, S.R.Utz. "Physical modelling of human skin optical properties using milk and erythrocytes mixtures" Proc SPIE ,
v 2627, #32.
3. V.V.Tuchin, S.R.Utz, I.V. Yaroslavsky."Tissue optics, light distribution, and spectroscopy", Optical engineering, Vol.33,№ 10, 1994.