SOL- GEL TREATMENT OF OPTICAL FIBERS

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Abstract
Sol gel is an interesting and perspective method of polymer surfaces modification. In this study is used SOL-GEL method based on hybrid polymers to chase the optical and other properties of optical fibres surfaces. The cationic dyes are used in different quantity to change the colour of fibres and improve the surface hardness of fibres.

Key words: SOL-GEL, OPTICAL FIBERS, CATIONIC DYES

1. Introduction

Optical fibers integrated into textiles were mostly explored for ilumination purposes or exception, although it was reported in the past on same applications. When integration of sensor into textiles in considered, optical fibers have a serious advantage over other kind of sensors due to their fibrous nature. The optical fiber is in some ways a yarn and can by ideally processed like standard textiles yarns. What is more, optical fibers can reliably operate as sensors in strong elektomagnetic fields, under nuclear radiation, in high temperatures,and in chemical enviroments. [1]
Optical fibers differs from silica optical fibers in materials and in dimensions. POF have much larger core diameter that means the accuracy of alignment between the light source and the fiber is less critical. POF typically consist of polymethylmethacrylat (PMMA) core adn a fluoropolymer cladding. The plastic nature of POF proviedes more-rugged fibers capable of withstanding light bend radii and measuring very high strain values of several ten percent without fiber breakage. The biocompactibility of POF should by additionally mentioned when considering applications in medicine. However, then main limition of POF are the relative high attenuation, which limits the operational range of the fobers to about 100 meters, and the relative low temperature of about 80°C at which the POF become non-usable.
Aim study is surface modification with a cationic dye that is applied to the fabric sol-gel method. Sol-gel method serves as a mechanical protection example before scratching.
Possibility of finishing surface properties of materials is deposition functional or inorganic top-coat by sol-gel method. One of advantages of this method is possibility of preparation thin layers on various materials. Up to now mainly inorganic substrates (glass, ceramic, metals etc.) were used, however thin layers can be deposited also on organic materials, especially on polymers.
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Principle of sol-gel method is preparation of homogeneous solution of starting components, which is transferred into sol by controlled hydrolysis and polycondensation [2]. This sol is deposited on surface of materials, transferred into gel and finally on layer of oxide by heat treatment. Layer of oxide is nonporous and glassy or crystalline at higher temperatures of heat treatment. However at lower temperatures of heat treatment it stays amorphous and porous. In a production and for research purposes SiO2 and TiO2 layers are deposited most often, also layers of many other constitutions containing $Al2O_3$, B_2O_3, ZrO_2, PbO and another oxides are usually prepared. Next to clearly inorganic layers also hybrid inorganic-organic layers are

developed (production terms ORMOCER, ORMOSIL and NANOMER) which contain also chemical bonding of organic substances and functional groups next to silicon, titanium, zirconium and oxygen. Preparing of very thin layers (10 up to 500 nm thick) of composite nanomaterials is further possibility of this method [2].
Layers prepared by sol-gel method are industrially used like reflex and antireflex layers in optics, protective, catalytic, modified and functional layers in material engineering and functional layers in microelectronics and biotechnology [2].

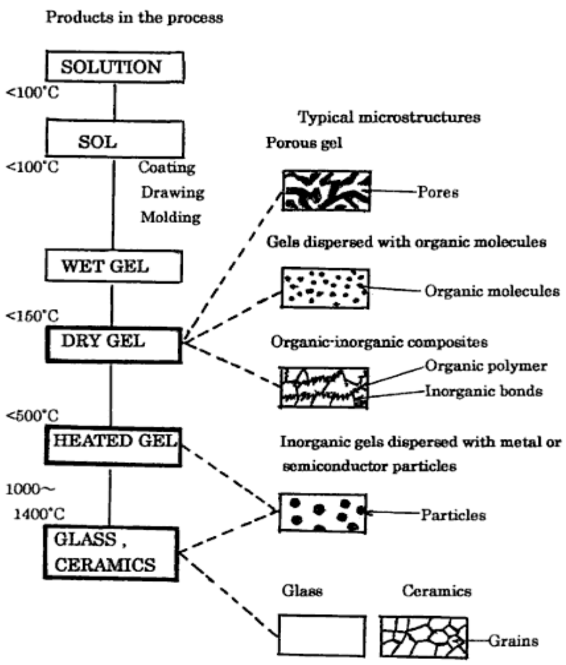

Figure 1. Steps of the sol-gel processing of materials and examples of the microstructure of final products. Bold-lined rectangles show possible final of the sol-gel method [3].

2. Experimental part

2.1 Infrared spectrometry

Infrared spectrometry found to be optical fiber was made from polyvinylidene fluoride (PVDF). PVDF is a highly non-reactive and pure thermoplastic fluoropolymer.

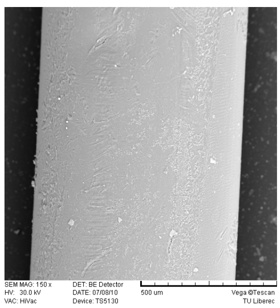

Figure 2. Optical fiber

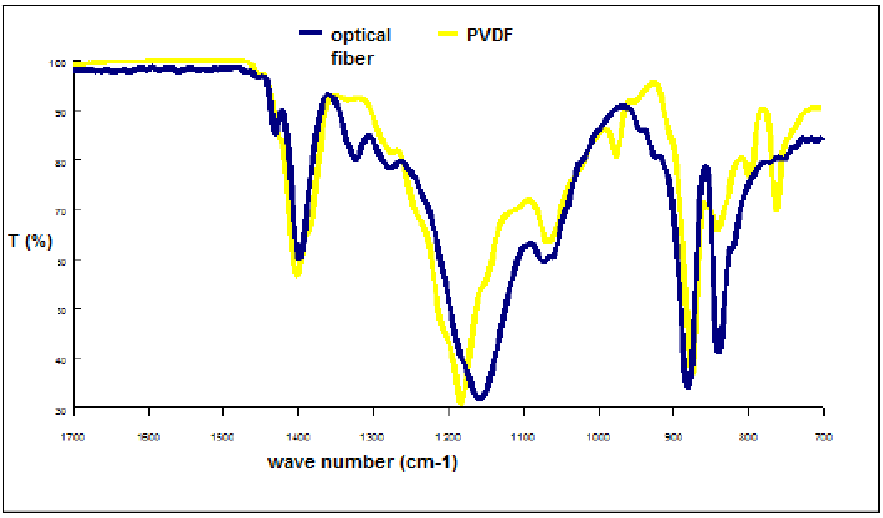

Figure 3. IR-spectrum of optical fiber

2.2 Cationic dye

Table 1. Cationic dyes for dying sol-gel method

Dyes	Code	C.I. name	C.I number
Astrozon Golden Yellow	GL-E	C.I Basic Yellow	28
Astrozon Red	FBL	C.I Basic Red	46
Astrozon Blue	FGGL	C.I Basic Blue	41

2.3 Sol description

Preparation of sol based TMSPM the basis for the preparation of sol was TMSPM ((3 -(trimethoxysilylpropylmethacrylate)

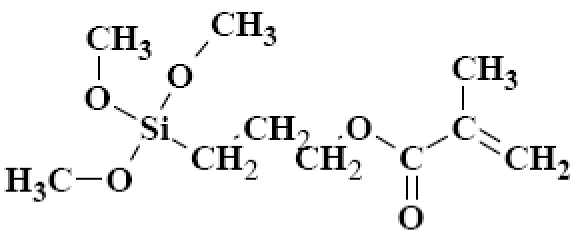

Figure 4. Chemical formula TMSPM

The principle consisted of sol dissolution TMSPM Mid required amount of IPA and the dissolution of other ingredients (water, HCl, BPO) in the second half of the required amount of IPA. Then the two solutions were mixed under vigorous stirring. Resulting sol was heated in boiling under reflux for 30 minutes after which the sol was cooled. Part of the final sol was diluted with IPA in the ratio 1:4. Sol (20ml) was mixed with 0,02g cation dye(Astrazon gold gelb GLE, Astrazon blau FGGL a Astrazon rot FBL). Final concentration was 1g/l.

2.4 Coating color layer sol-gel

Optical fibers were cleaned in a solution dichlormathanu. Fibers in the solution was 10min. After 10min was rinsed in water. On filter paper were dried freely.
Colour coating sol was coated onto the optical fiber dip-coating method. The fiber is first dipped in a solution of the solute, then went up approximately constant speed, and finally inserted in the oven for 1 hour at 90 ° C. This procedure was repeated than equal 10 deposited layers.

2.5 Evaluation of coloration

Optical fibers were dyed ostacet red SB and us. SG blue (for 15min, 30min, 45min and 60min), was photographed in the cell (width 0.2 cm), which was filled with tetrafluoroethylene (approximately the same refractive index as polyvinyldienfluor n = 1.43).
Calibration was performed with colored solutions and the different concentration of tetrafluoroethylene (0,2g/l, 0,1g/l, 0,02g/l a 0,0g/l) Photo shoot took place with a camera Canon in constant conditions. In Figure 3 is shown a way the photo shoot. Photos were processed in ImageJ. The values of coordinates RGB color system were prepared calibration curve and subtracted them dye concentration on the fiber.

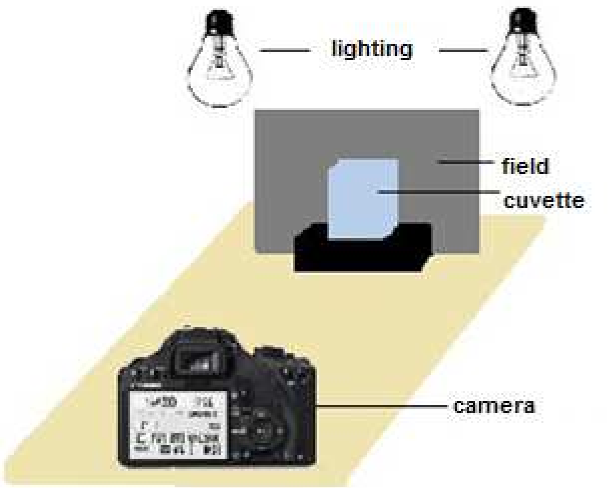

Figure 5. Photography System

3. Results and discussion

Optical fibers with sol-gel layers were photographed in the cell (width 0.2 cm), which was filled tetrafluoroethylene. Photos were processed in ImageJ. The values of color coordinates of RGB system, it was found that the dye concentration increases proportionally with the number of deposited layers, as shown by Fig 6, 7, and 8. With the increasing number of colored sol-gel coatings is a shade darker.

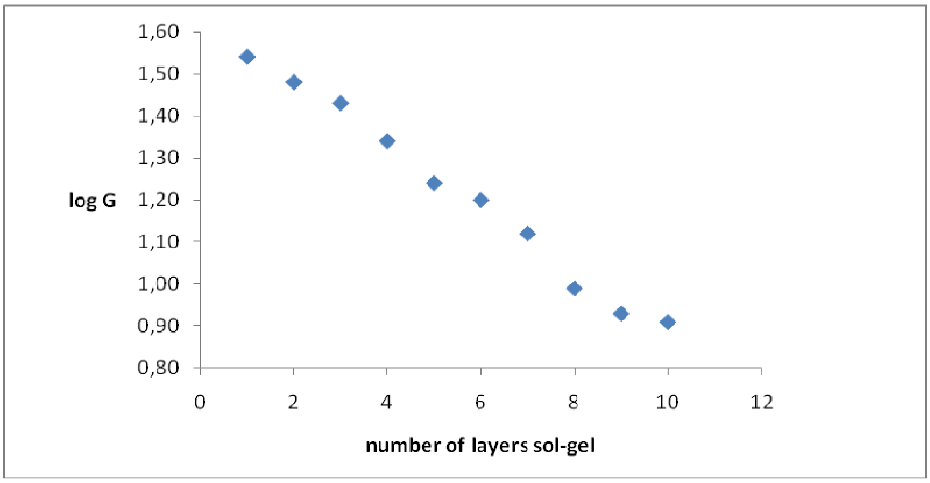

Fig 6. Astrozon Red FBL logG

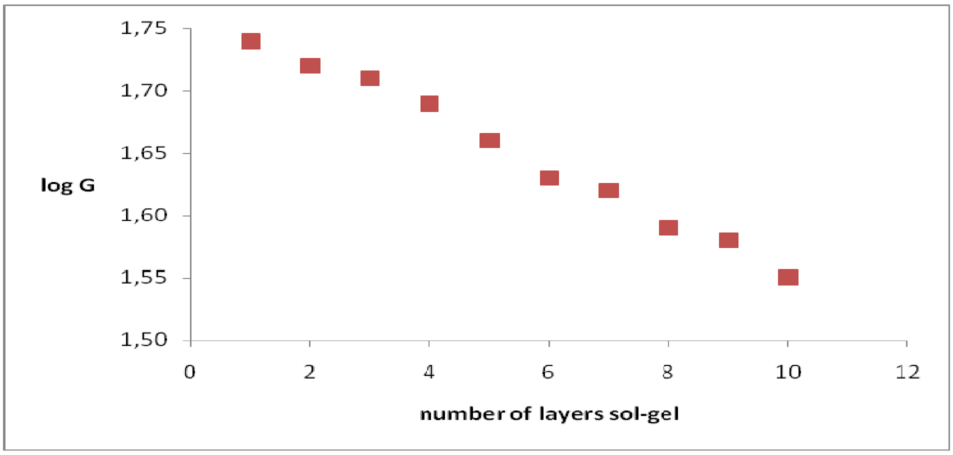

Fig 7. Astrazon Blue FGGL logG

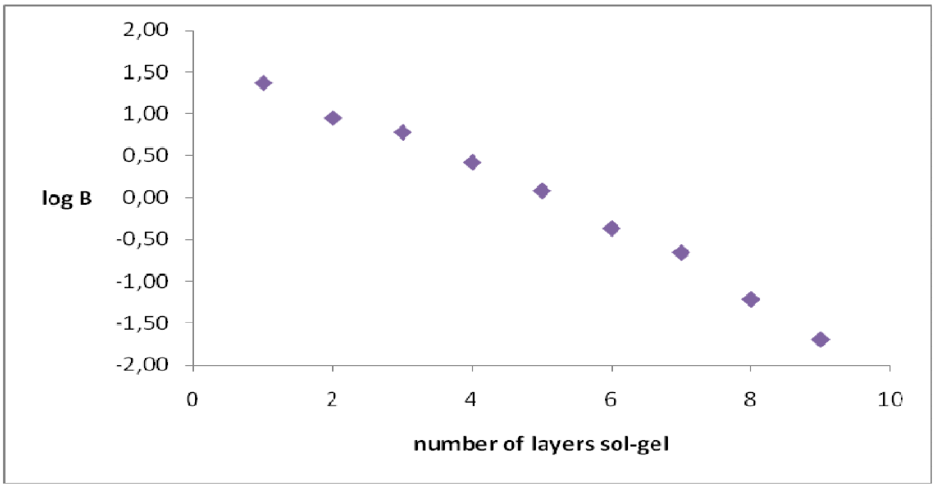

Fig 8. Astrozon Golden Yellow logB

Figure 6, 7 and 8 shows the dependence of the logarithms of RGB color coordinates the number of layers deposited sol-gel. Increasing number of sol-gel layers with increasing concentrations of dye in fiber optics, which is reflected in a decrease of values of logarithms of RGB color components.

Table 2. The values of logarithms of RGB color coordinates

number of layers sol-gel	Astrozon Red FBL logG	Astrozon Blue FGGL logG	Astrozon Golden Yellow GL-E logB
1	1,54	1,74	1,37
2	1,48	1,72	0,95
3	1,43	1,71	0,78
4	1,34	1,69	0,42
5	1,24	1,66	0,08
6	1,20	1,63	-0,37
7	1,12	1,62	-0,66
8	0,99	1,59	-1,22
9	0,93	1,58	-1,70
10	0,91	1,55	-2,00

By image analysis Lucia was monitored distribution of dye in the fiber. Figure 7 shows dye only in the surface fibers.

Fig.9 : Astrazonred FBL 10 layers sol-gel

4. Conclusion

Dyeing with cationic dyes deposited on fibers using sol-gel method to achieve an increase in color after repeated deposition of layers. These layers of optical fiber can serve as a protective film against scratches or other mechanical degradation. Dyeing is only the surface fibers into the dye and remain insufficiently due to the surface layer. Light transmission optical fiber does not change color.

5. References

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