SEM, EDX AND UV SPECTRUMS OF Fe_2O_3 DOPED SODA-LIME-SILICA GLASSES*

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The aim of this work is to produce colored glass, used in light filter fabrication, by doping Fe_2O_3 into soda-lime-silica glass (doping ratio 1:100, 3:100 and 5:100). SEM, EDX and UV analysis were conducted for the three different doping rates. Surface distribution properties of the doped glass were investigated by using SEM technique, molecular content and light transmittance characteristic were studied by using EDX and UV techniques, respectively.

Key words: Soda-lime-silica glass, colored glass, light filter, SEM, EDX, UV Spectrum.

1. INTRODUCTION

Glass is a material which we commonly use in daily life and scientific studies. It is a solid with an amorphous structure. It forms with the cooling of the constituting elements from liquid phase at a rate which will hinder the conversion of the elements to crystal structure.

Thousands of different chemical compositions can be made into glass. The most commonly produced glass is soda-lime-silica glass which accounts for about 90 percent of all the glass produced [1]. These glasses are used in the fabrication of all types of cup, flat glass, window glass, kitchen kits, light filter, etc. Generally, its composition takes values between 70–74% for SiO_2, 10–13% for CaO and 13–16% for Na_2O. Different alkali oxides can be added to develop physical and chemical properties of glass [2].

A variety of colors in glasses are caused by transition metal ions in them, often in small concentrations. Thus the green color observed for thick slabs of most commercial glasses results from absorption of impurity ferric ions in the glass, and some absorption of this ion in the ultraviolet persist even when it is present in concentrations of less than 1 part/million [3].

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If 3d elements such as Fe, Co, Ni, Cu, Cr, U, and so on are incorporated in colorless base glasses, the simplest type of colored glasses, the so-called "ion-colored filter glasses" are obtained [4]. The obtained color changes with the structure of bulk glass, doping material and doping rate.

2. EXPERIMENTAL

In this work, soda-lime-silica glass has been selected for coloring as base glass. The glass used is included nearly: 71% SiO_2, 1.5% Al_2O_3, 8.5% CaO, 3.5% MgO, 15%Na_2O, 0.5% (Fe_2O_3 + TiO_2 + K_2O + SO_3 + P_2O_5 + CoO + SeO). Fe_2O_3 is doped into prepared glass bulk at three different doping rates: 1%, 3% and 5%. Each glass bulk doped at these rates with Fe_2O_3 held in a platinum pot and exposed to 1400°C in a high temperature oven during 24 hours. After this process, the glass poured quickly and formed and then put into an annealing oven at 600°C. The temperature of the oven lowered gradually by intervals of 100°C in an hour, and after 300°C the sample reduced to room temperature, then the sample cut in a parallel form ~ 2–3 mm thickness. The transmission values versus wavelength of all samples investigated with a UV spectrometer (UV2-100 UV/Visible Spectrometer). Also the SEM micrographs and EDX analyses of the samples were taken with Jeol JSM-5600 LV and Noran Voyager-EDS 3050 respectively.

3. RESULTS AND DISCUSSION

3.1. UV MEASUREMENTS

Fig. 1 shows the UV spectrum of the base (undoped soda-lime-silica) glass. In this spectrum the peak at 380 nm belongs to Fe^{+3}. The other peaks belong to the ions (Co^{+2}, Se) in low amounts used to uncolourize the glass.

The UV spectra of the Fe_2O_3 doped soda-lime-silica glasses (at the doping rates of 1%, 3% and 5% respectively) can be seen in Fig. 2. In all spectra, maximum transmission in visible region can be seen about 500–550 nm. Thus, soda-lime-silica glasses doped Fe_2O_3 is green. Absorption spectrum of ferric iron ions gives three weak absorption bands about 380, 420 and 435 nm [5]. In the first sample, doped iron ions as uncolorize the glass has been given peak in 380 nm and covered the other peaks in spectrum of the uncolored glass. In generally, the absorption of Fe^{+2} is increasing from 600 nm [5]. In this study, the transmission in UV spectra is decreasing after 60 nm. We can say that Fe^{+2} quantity of doped glasses increase on the contrary uncolored glass. Thus, a part of Fe^{+3} ion which is

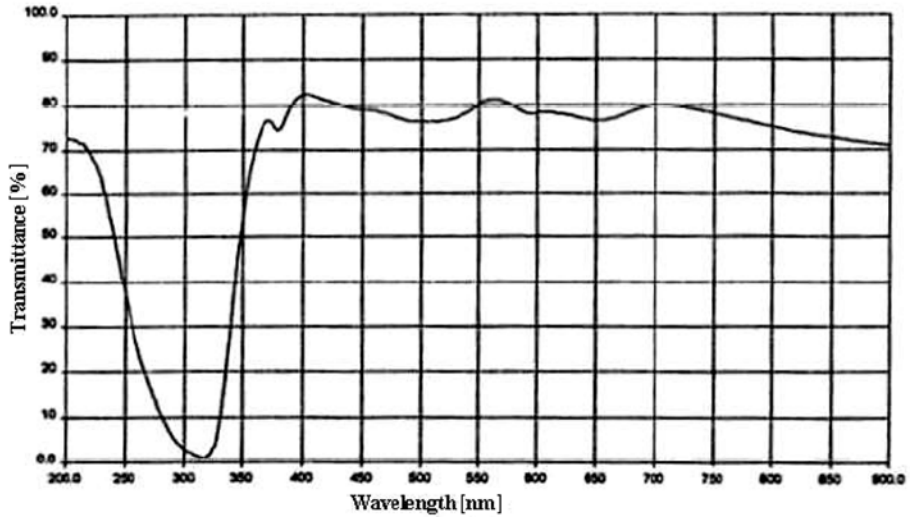
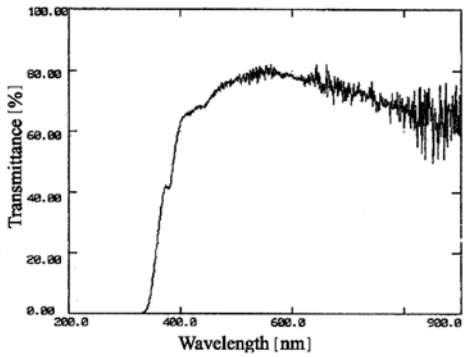
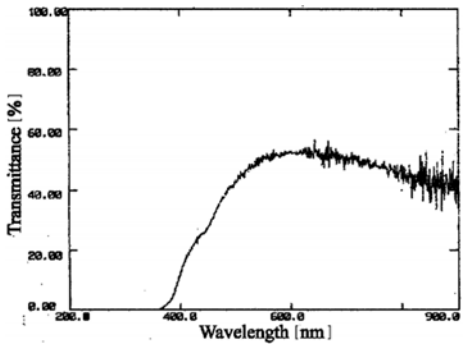


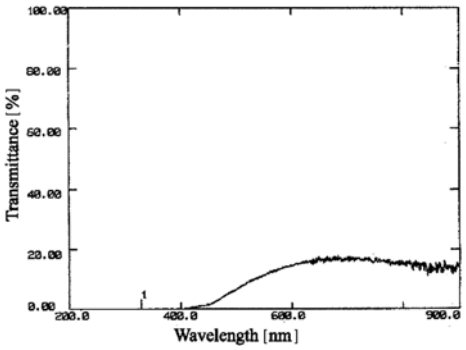
Fig. 1. – UV Spectrum of base glass.



a) Fe_2O_3 doped 1%



b) Fe_2O_3 doped 3%



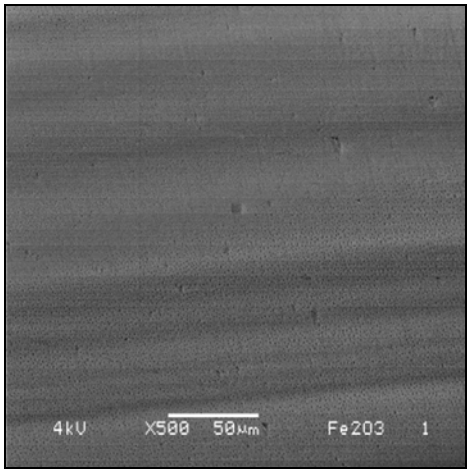
c) Fe_2O_3 doped 5%

Fig. 2. – UV spectra of the Fe_2O_3 doped soda-lime-silica glasses.

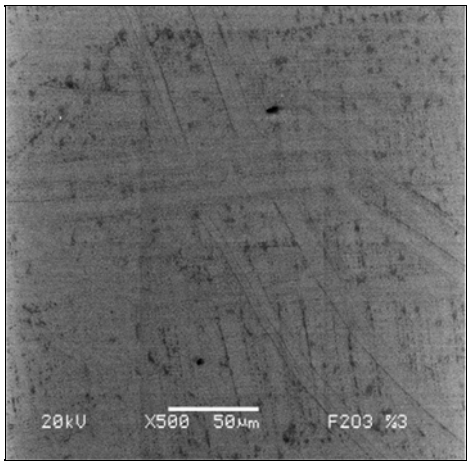
doped as Fe_2O_3 transformed to Fe^{+2} during the formation of glass. Besides, it was seen that the transmission is decreasing with increasing doping rate.

3.2. SEM MICROGRAPHS

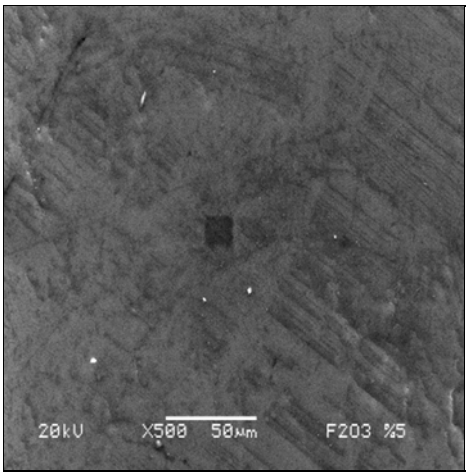
The SEM micrographs of the soda-lime-silica glasses doped with Fe_2O_3 at the percentages of 1, 3 and 5 are shown in Fig. 3, respectively. In SEM micrographs are nearly perfect homogeneous and unsolved particles are not seen. Doping Fe_2O_3 of soda-lime-silica glass has got a fine surface feature.



a) Fe_2O_3 doped 1%



b) Fe_2O_3 doped 3%



c) Fe_2O_3 doped 5%

Fig. 3. – SEM micrographs of the Fe_2O_3 doped soda-lime-silica glasses.

3.3. EDX MEASUREMENTS

Elemental analyze of glass samples has been done using EDX. Existence of elements which are expected in structure of glass is proving. In Table 1, a great deal of the glass is formed by silicon. In the colored glass which measures iron rate is much greater than the doping rate. Thus, we can say that iron ions have been found in the structure of the glass. Since the class has amorphous structure, elemental weights of three samples are not same.

Table 1

EDX table of the Fe_2O_3 doped soda-lime-silica glasses at 1%, 3% and 5% rates

Element	Elementary Weight		
	1% Fe_2O_3	3% Fe_2O_3	5% Fe_2O_3
Si	43.54	39.02	37.57
Al	5.57	7.40	7.68
Na	3.64	4.30	4.64
Ca	11.03	10.64	8.69
Mg	0.77	1.43	0.93
Fe	1.14	3.94	5.13
O	32.65	32.13	34.12
P	0.15	0.00	0.06
S	0.89	0.15	0.12
K	0.04	0.52	0.16
Ti	0.59	0.48	0.90

4. CONCLUSION

In this study, the iron ion which is a transition metal ion has been doped in soda-lime-silica glass with oxide state. Soda-lime-silica glass doped iron has been given green color and the doping rate is increased with decreased the transmission. Furthermore, the sample surface is seen in homogeneous structure by SEM micrographs. Consequently, soda-lime-silica glass which is doped Fe_2O_3 will be produced as a good quality light filter.

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