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FAR INFRARED TRANSMISSION PROPERTIES OF ENAMEL LACQUER AND THE POSSIBILITY OF ITS USE FOR INCAPSULATION OF OPTICAL DEVICES

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For three types of lacquer far infrared transmission measurements were performed in the range between 40 and 400 cm^{-1}. It has been shown that lacquer is very transparent in that range and that it can be used for incapsulation of optical devices which work in the far infrared range.

Introduction

It is well known that there are various materials which are more or less transparent in the visible and infrared range. Meanwhile there are not so many materials which are transparent in the far infrared range. In figure 1. are given the ranges of transparency for a row of dielectrics and semiconductors (1). It is obvious that that dielectrics are more transparent in both visible and near

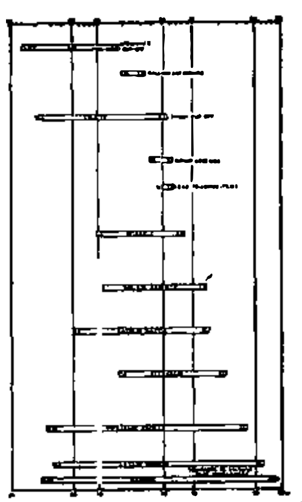

Fig. 1. Transmission regions for a row of dielectrics and semiconductors. The limiting wavelengths are chosen as those wavelength at which a sample 2 mm thick has 10% transmission; with asterisk(*) are marked materials which external transmission is less than 10%.

infrared ranges compared with semiconductors. CeJ and diamond have the widest spectra of transparency. CeJ has a transmission edge limitation at a wavelenght of about 80 microns while diamond is transparent in a very wide range even up to a wavelenght of one milimeter. Here the high price of diamond shuld be taken into account so it is used only in special situation.

In this work is given the transmission characteristic for enamel lacquer which is very transparent in the far infrared range and whose other physical properties are very good compared with other transparent materials.

Experimental results

Samples of enamel lacquer in the shape of a strip 4 cm wide and about 10 cm long were made under similar technological conditions to those which are normally used during lacquering of copper wire with enamel. The samples were made in the research and development laboratory of the cable factory "Moša Pijade" in Svetozarevo. We have examined the following types of lacquer: polyamide polyurethane, polyvinyl acoustal and thermoplastic lacquer.

In figure 2 is given the infrared transmission curve for polyamide polyurethane lacquer as a function of the wavenumber obtained with a Perkin Elmer 577 spectrophotometer.

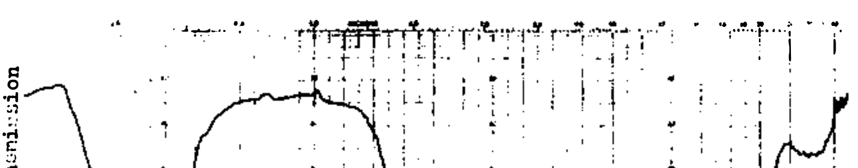

Fig. 2. Infrared transmission for polyamide polyurethane enamel lacquer.

One can see that this lacquer is transparent in a relatively narrow range between 1750 and 2840 cm^{-1}, and also in the range which is approching the wave number of 400 cm^{-1}. It can also be noticed that this lacquer has two rather well exposed absorption peaks at about 2920 and 3300 cm^{-1}. That is the consequence of the molecular structure of this lacquer. For polyvinyl acoustal and thermoplastic lacquer the infrared transmission diagrams are similar to figure 2.

Far infrared transmission characteristics were obtained for these materials using a Fourier spectrometer (Beckman FS720).

In figure 2 is given a transmission diagram for polyamide polyurethane in the range between 80 and 400 cm^{-1}.

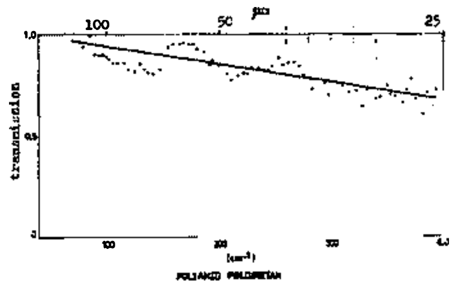

Fig. 3. Far infrared transmission diagram versus wavenumber for polyamide polyurethane enamel lacquer.

The experimental points are represented by dots while the full line expresses the average value of the transmission. Similar diagrams for polyvinyl acoustal and thermoplastic lacquer are given in figures 4 and 5 respectively.

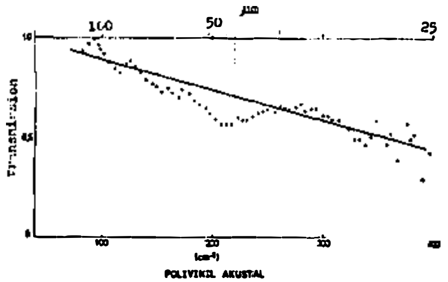

Fig. 4. Far infrared transmission versus wavenumber for polyvinyl acoustal enamel lacquer.

It can be seen that, for the latter materials, the transmission edge is moved towards a lower range which should mean that enamel lacquer is not wholly transparent in the infrared range.

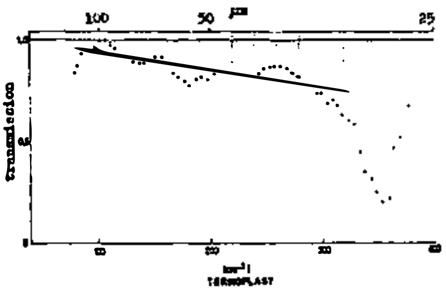

Fig. 5. Far infrared transmission versus wavenumber for theroplastic enamel lacquer.

Discussion of results

Using the results given in diagrams 3,4 and 5 it can be said that the enamel lacquer polyamide polyurethane and polyvinyl acoustal are very transparent in a relatively wide range between 30 and 400 cm^{-1} namely, between 152 and 24 microns. Only arbitrary values of transmission are given in these pictures so that it should be emphasised that the examined lacquers are very transparent even when they are rather thick (several hundreds of micrometers). It is important to say that from the practical point of view it is very easy to make thin strips of lacquer with the thicknesses of about 10 micrometers. In that case the transmission is about 100%. The thickness of the enamel lacquer which is usually used to isolate copper wire is about 12 micrometers. Enamel lacquer also has very good mechanical characteristics. It is not hydroscopic either and it can be used at temperatures much above $100^{o}C$.

We are going to mention another material which is very transparent in the far infrared range, this is polyethylene. Its transmission curve as a function of wavenumber is given in figure 6. If we compare polyethylene with enamel lacquer one can say that it is possible to use the latter at a higher temperature and it is very suitable as a window for far infrared devices. The procedure fo making windovs can be very simple as well. It is probably enough just to dip the device into the liquid lacquer and then to dry it at a temperature below $400^{o}C$.

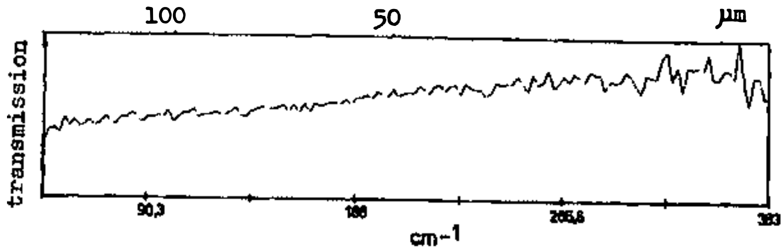

Fig. 6. Far infrared transmission versus wavenumber for polyethylene.

In conclusion it is possible to say that enamel lacquer is better than the other materials for use as a window in far infrared ranges because first of all it can be used at rather high temperatures, it seals well, is not hydroscopic and it is extremely cheap. Thus in our opinion it can be a useful material for making windows in the far infrared range for incapsulation of optical devices.

REFERENCES

1. S.S.Ballard, K.A.Mc Cathy, and W.L.Wolte, American Institute of Physics Handbook, 2nd Ed.Mc Grow-Hill, New York (1963), Sec. 6, p. 11.