SPECTRAL TRANSMITTANCE OF POLYMER OPTICAL FIBRES BEFORE AND AFTER ACCELERATED AGEING

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1. Introduction

Main application fields of Polymer Optical Fibres (POF) are illumination, signalisation and displays. Displays (e.g. variable message signs) and traffic signals (e.g. road, railway or harbour signalisation) for traffic control based on POF are gaining increasing market share. During operation they are influenced by several environmental stress factors (e.g. temperature, humidity, vibration). Due to the environmental stress a change of their performance can occur. For a high degree of traffic safety it is necessary, to investigate the reliability and functionality of such systems, especially of the used POF and the stability of their spectral transmittance in the visual spectral range in colorimetric terms.

With regard to a possible change of spectral transmittance caused by environmental stress factors during a supposed operation time of 10 to 15 years, the ageing influence of temperature and humidity as very important stress factors was investigated.

2. Test Method

To generate an accelerated ageing process, a test method based on the standard ISO 2578:1993 ´Plastics - Determination of time-temperature limits after prolonged exposure to heat´ was used. As an indicator for the ageing process of the POF, the loss of transmittance was chosen. Typical POF-step-index fibres for display applications were stored in a climatic chamber at defined temperatures in a range of 88 °C to 92 °C in combination with a relative humidity of 95 %RH. For each POF type and ageing temperature five samples were tested. The length of each stressed fibre was 10 m. During each ageing procedure, an on-line transmittance measurement at a wavelength of λ = 660 nm was performed. The criterion for stopping an accelerated ageing procedure was set to a loss of transmittance to τ = 50 % at λ = 660 nm. In addition to the on-line measurements, the spectral transmittance of the fibres was measured before and after the accelerated ageing procedure in a wavelength region of λ = 370 nm to 770 nm. Taking into consideration possible differences between the samples, an average spectral transmittance curve was calculated from each sample set (five samples). Based on these average spectral transmittance data, chromaticity coordinates were calculated for standard illuminant A and different fibre lengths.

3. Results

The results of the spectral transmittance measurements show for all tested POF the expected overall deterioration of the transmittance characteristic within the visual spectral region after the ageing process. In addition a change of the spectral transmittance characteristic in a wavelength region of λ = 370 nm to 490 nm can be observed for all tested POF. In comparison to the overall deterioration, this variation of the transmittance curve is generally very small and differs between the tested POF.

Depending on the fibre length, the chromaticity coordinates show more or less significant color differences before and after ageing. The importance of these color changes concerning traffic safety can be assessed by comparing them with the demands of the European standard for ´Road vertical signs; Variable message traffic signs´ (draft 1995).

At short fibre lengths up to 1.5 m the color changes due to ageing are very small. Figure 1 shows typical chromaticity coordinates of a qualified POF with this fibre length. Based on standard illuminant A, the requirements for the color sections Red, Green, Blue and White/Yellow are fulfilled by most of the tested POF. By use of qualified or filtered halogen lamp, the requirements of the separated color sections White and Yellow can also be achieved. A problem can be the Green area. Already before the ageing, the chromaticity coordinates of one tested POF are located outside the specified color sections.

With increasing fibre length, the color alteration becomes more significant. For a qualified POF with a fibre length up to 10 m, the requirements for the color sections White/Yellow can be achieved before and after ageing. Difficulties can arise for other color ranges, especially for fibre lengths beyond 5 m.

4. Conclusions

Qualified POF with short fibre length can be used for displays and traffic signals without any loss of reliability and traffic safety due to ageing. In combination with a qualified or filtered halogen lamp, aged POF fulfill the strict requirements of class D1 of the European standard for ´Road vertical signs; Variable message traffic signs´. Applications with longer fibre lengths seem also to be possible for specific color sections like White/Yellow. To fulfill the strict requirements of class D1 with longer fibre lengths, the ageing behaviour of POF must be improved.

Fig. 1: Typical Chromaticity Coordinates