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High refractive index silica-titania glass for optical fiber sensoring of liquid fuels

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Abstract – High refractive index silica-titania glass was synthesized by the VAD (Vapor-phase Axial Deposition) technology for optical fibers sensors in order to increase the sensibility of Fresnel-based reflectometers for liquid fuel sensoring.

Since the introduction of biofuels for automotive vehicles to be used as main fuel or to be added to conventional fuels, the precise measurement of mixture concentrations has been important to the quality control and normalization of these new types of fuels. The Fresnel reflectometer is a low cost optical fiber based sensor that provides online and real-time precise measurements of the refractive index of liquids ($\Delta_n \sim 10^{-4}$) [1] and presents many advantages over conventional sensors for liquids identification and concentration measuring of liquid mixtures [2]. However, as the reflective intensity is given by the Fresnel formula $(n_f - n)^2/(n_f + n)^2$, where n_f and n are the refractive indices of the fiber and liquid, respectively, some fuels such as gasoline and diesel/biodiesel incurs in some measuring difficulties for having refractive indices very close to standard optical fibers commonly used in these reflectometers.

This research reports the development of high refractive index silica-titania glass preforms synthesized by the VAD (Vapor-phase Axial Deposition) technology [3] for optical fibers sensors with improved sensibility for Fresnel-based reflectometers. High refractive indices were achieved by using TiO_2 as the main dopant for silica (Figure 1). SiO_2 and $TiCl_4$ halides were used as precursors for SiO_2 and TiO_2 oxides, respectively. Preforms with different doping concentrations were produced by controlling the $TiCl_4$ carrier gas flux during the preform deposition. Glass preforms with refractive index $n_D \sim 1.50$ were obtained with TiO_2 concentration around 9 mol %. Preforms with higher TiO_2 concentration presented some crystallization level due to TiO_2 clustering formation and opacity after the consolidation process at 1400 °C, although current studies indicate that a heavy doping can be achieved by increasing the consolidation temperature ($T > 1500$ °C). However, even when a fiber with refractive index of about 1.50 is used, water-ethanol, ethanol-gasoline, and ethanol-diesel/biodesel scales can be increased by 33 %, 54 %, and 76 % (Figure 2), respectively, a considerable boost in the optical sensibility.

In conclusion, a silica-titania glass with high refractive index glass can be synthesized by the VAD method for optical fiber sensors, improving the performance of Fresnel-based refletometers for liquid fuels sensoring.

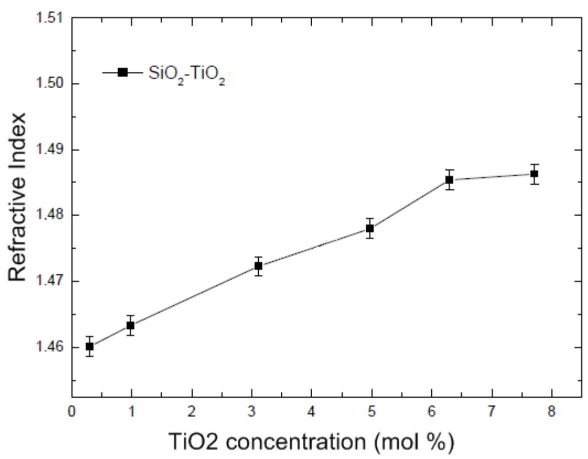

Figure 1: Refractive index dependence with TiO_2 concentration.

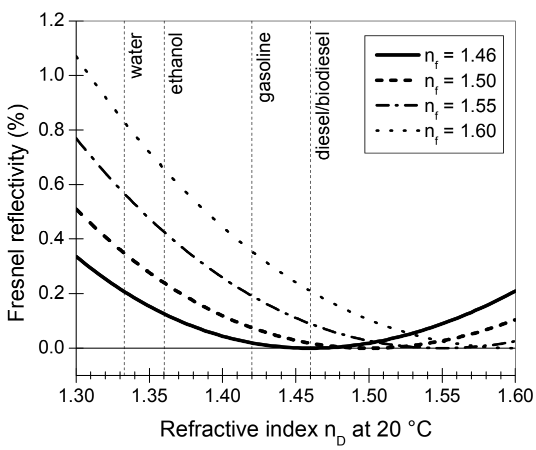

Figure 2: Sensibility improvement by using high refractive index optical fibers.

References

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