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Pressure induced changes to titanium phosphate glass

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Titanium phosphate ($\text{TiO}_2\text{-P}_2\text{O}_5$) glasses are interesting materials due to their unusual glass forming range with high (65-75%) TiO_2 content, making them fascinating subjects to study from a structural point of view. The as-made glasses are dark due to the presence of a small amount of Ti^{3+} . They can be bleached to colorless glass when held in air for extended time at a temperature around T_g , resulting in pure Ti^{4+} -glasses as confirmed by EPR. We have subjected an Al-doped ($5 \text{ Al}_2\text{O}_3:67.5\text{TiO}_2:27.5\text{P}_2\text{O}_5$) glass sample at T_g to a moderate pressure of 1GPa. Physical properties, including density, hardness and crack probability have been measured on both non-pressurized and pressurized samples. In addition, structural information has been obtained from Raman and MAS NMR spectroscopy. After pressurization a density increase of 6% is observed as well as an increase in hardness and crack probability. ^{31}P MAS NMR indicates that the uncompressed glass consists mainly of Q^1 and Q^0 phosphate groups. The glass appears to become more depolymerized after the pressure treatment. A corresponding increase in both the proportion of 6-fold coordinated Ti and the fraction of higher coordinated Al species is also observed. These structural modifications can be correlated with the measured changes in physical properties.