Enhancing Electrical Conductivity and Catalytic Activity Through Controlled Crystallization of V_2O_5-Nb_2O_5-P_2O_5 Glass

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Glassy and glass-ceramic materials based on V_2O_5-P_2O_5 have been identified as highly promising cathode materials for rechargeable Li-ion, Na-ion, and all-solid-state batteries. These materials offer a compelling combination of high safety, exceptional energy density, and extended cycling life, making them highly promising[1]. In addition, such materials are also recognized as effective catalysts in oxidation reactions[2]. Furthermore, it has been acknowledged that the microstructural properties, electrical conductivity, and electrochemical properties of V_2O_5-P_2O_5-based glasses can be significantly improved through thermally controlled crystallization[3]. In light of this, this study aims to synthesize a glass with a nominal composition of $70V_2O_5$-$20Nb_2O_5$-$10P_2O_5$ and investigate the influence of controlled crystallization at different temperatures and durations on the electrical and catalytic properties. The parent glass is prepared via the melt-quenching technique, and its thermal behavior is examined through differential thermal analysis (DTA). The samples subjected to controlled crystallization are qualitatively and quantitatively analyzed using powder X-ray diffraction (PXRD), while (micro)structural properties are assessed using scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS), and infrared attenuated total reflectance spectroscopy (IR-ATR). Electrical transport is investigated by solid-state impedance spectroscopy (SS-IS) across a wide frequency (0.01 Hz to 1 MHz) and temperature range (–90 °C to 240 °C). The catalytic activity of prepared samples is tested in oxidation reactions of stearic acid and is monitored using TG-IR system. The findings of this research demonstrate a remarkable enhancement in electrical conductivity through thermal treatment of the parent glass, with the sample heat-treated at 380 °C exhibiting the highest conductivity of 1.58×10^{-3} S/cm @30 °C. Furthermore, these materials exhibit promising catalytic properties, unveiling new avenues for their application.

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