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# A Study of Interfacial Processes Between Metal Oxide Nanostructured Thin Films and Ionic Liquids for Potential Applications in Photoelectrochemistry

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Since the thought of mimicking photosynthesis in plants by creating Dye-sensitized Solar Cells (DSSCs) has been conveyed in the 90s, the interest kept growing within research laboratories to improve their efficiency. DSSCs are considered to be viable alternatives for tackling the issue of lengthy and expensive manufacturing processes of silicon-based photovoltaic solar cells. However, commonly used electrolytes employed in DSSCs are often based on high volatile organic solvents - a detrimental characteristic which poses a key issue for the implementation of stable devices.

Several options are being investigated worldwide and ionic liquid-based electrolytes could be suitable alternatives to these organic solvents. Indeed, room temperature ionic liquids (RTILs) can have low volatility, high-ionic conductivity and wide electrochemical potential windows.

In this work, we probed interfacial processes taking place at nanostructured metal oxide/ionic liquid interfaces, adopting the electrolyte gating approach. The principle of electrolyte gating is known since almost 60 years, having been used in the early works of Shockley, Bardeen and Brattain. It relies on the use of electrolytes as gating media to modulate the conductivity of semiconducting thin films. Specifically, we employed the electrolyte-gated (EG) transistor configuration, where an electrolyte replaces the gate dielectric used in more conventional field-effect transistor structures. In EG transistors, the application of a gate voltage induces the formation of an electrical double layer at the electrolyte/semiconductor (metal oxide) interface.

We fabricated and characterized EG transistors based on solution-processed thin films of metal oxides of relevance for photoelectrochemistry applications ($WO_3$, $TiO_2$, ZnO) and making use, as the electrolyte, of different ionic liquids, such as [BMIM][PF6], [BMIM][TFSI], [EMIM][TFSI]. By electrochemical impedance spectroscopy, we obtained the capacitance of the electrical double layers with the aim to obtain information on charge transport in metal oxide thin films (e.g. electron mobility). A tentative correlation between the effectiveness of the gating (i.e. the modulation of the conductivity of the metal oxide thin film) and the ionic conductivity, viscosity, and ion size of the ionic liquids is proposed.

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