

# Hole transporting behavior of Tin (IV) hybrid defect perovskites combining $(\text{CH}_3)_3\text{S}^+$ cation and halide anions

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**Abstract** Tin (IV)-based air stable hybrid defect perovskites combining trimethyl sulfonium  $[(\text{CH}_3)_3\text{S}^+]$  cation with various halide anions (Cl, Br, I) have been synthesized and characterized. The trimethyl-sulfonium cation can be an alternative of the humidity sensitive methylammonium (MA) and formamidinium (FA) cations, which are commonly used in perovskite solar cells (PSCs) [1] that recently revolutionized the field of third generation photovoltaics with power conversion efficiency (PCE) exceeding 23% [2]. The XRPD patterns and corresponding Rietveld analysis show that the  $((\text{CH}_3)_3\text{S})_2\text{SnX}_6$  ( $\text{X} = \text{Cl}, \text{Br}, \text{I}, \text{I}_5\text{Cl}, \text{I}_4\text{Cl}_2, \text{I}_5\text{Br}, \text{I}_4\text{Br}_2$ ) perovskite compounds crystallize in the cubic 0D framework. According to Raman investigation, their lattice vibrations depend largely on the nature of halogen anion. UV-vis diffuse reflectance spectra confirmed that similar dependence was observed for their band gaps ranging from 1.38 to 4.0 eV. After their physicochemical characterization, the novel perovskites were successfully incorporated as hole transporting materials in solar cells (DSCs) using different sensitizers (both organic dyes and transition metal complexes) chemically adsorbed on titania mesoporous electrodes, where power conversion efficiencies as high as 5% were achieved. The obtained results is a significant step forward the development of solution processed, lead-free solid-state third generation photovoltaics (dye-sensitized and/or perovskite solar cells), presenting enhanced performance, low fabrication cost and high stability [3,4].

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