# Hole Transporting Layers for Printable Perovskite Carbon Based Solar Cells

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## Abstract

Since their first appearance in 2009, Perovskite solar cells (PSCs) have emerged as a highly promising solar technology, often surpassing the efficiency records of monocrystalline silicon photovoltaics. Carbon electrodes have garnered significant attention as a viable alternative to noble metal electrodes traditionally used for PSCs, due to their cost-effectiveness, stability, and scalability. Carbon-based PSCs (C-PSCs) can be processed with or without hole-selective layers (HSLs). However, for traditional HSL-free C-PSCs, the absence of an HSL has been identified as a key factor limiting their performance. The direct contact between the perovskite and the non-charge-selective carbon electrode has been recognized as a significant source of interfacial resistance loss, resulting in poor hole selectivity and recombination loss. In the literature, research studies are available concerning both organic and inorganic HTLs. In this work, both options were tested: inorganic, using CIS ($CuInS_2$), and organic, employing poly(3-hexylthiophene-2,5-diyl) (P3HT). Additionally, in the latter case, the potential of introducing a 2D material, specifically rGO (reduced graphene oxide), was also explored. The architecture of our C-PSCs includes the following layers: a glass substrate; a layer of fluorine-doped tin oxide (FTO);

an ETL; a perovskite absorber ($FAPbI_3$ formulation by air-assisted blade coating); an HTL; and a low-temperature carbon electrode. The goal of our experimentation is focused on reducing the performance gap that exists between the cells with gold counter electrodes, with which we have achieved an efficiency of 20,84%, and those with carbon electrodes.

## Keywords

Perovskite Solar Cell, Carbon Electrode, Hole Transporting Layer