

## Article

# Solvent Effects on the Structural and Optical Properties of MAPbI<sub>3</sub> Perovskite Thin Film for Photovoltaic Active Layer

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**Abstract:** Controlling the crystallinity, homogeneity, and surface morphology is an efficient method of enhancing the perovskite layer. These improvements contribute toward the optimization of perovskite film morphology for its use in high-performance photovoltaic applications. Here, different solvents will be used in order to process the perovskite precursor, to improve the interfacial contacts through generating a smooth film and uniform crystal domains with large grains. The effect that the solvent has on the optical and structural properties of spin-coated methyl ammonium lead iodide (MAPbI<sub>3</sub>) perovskite thin films prepared using a single-step method was systematically investigated. The spin-coating parameters and precursor concentrations of MAI and PbI<sub>2</sub> were optimized to produce uniform thin films using the different solvents N, N-dimethylformamide (DMF), dimethyl sulfoxide (DMSO), and  $\gamma$ -butyrolactone (GBL). The effect that the solvent has on the morphology of the MAPbI<sub>3</sub> films was examined to determine how the materials can be structurally altered to make them highly efficient for use in perovskite hybrid photovoltaic applications. Scanning electron microscopy (SEM) and X-ray diffractometry (XRD) results show that the synthesized MAPbI<sub>3</sub> films prepared using DMSO, DMF, and GBL exhibit the best crystallinity and optical characteristics (photoluminescence (PL)), respectively, of the prepared films. The optical properties resulting from the noticeable improvement PL of the films can be clearly correlated with their crystallinity, depending on the solvents used in their preparation. The film prepared in DMSO shows the highest transmittance and the highest bandgap energy of the prepared films.

**Keywords:** perovskite; CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub>; solvent additive; morphology; optical properties; photovoltaics materials



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## 1. Introduction

Organic-inorganic halide perovskites (OIHPs) have received much attention recently as potential light-absorbing materials for use in photovoltaic applications [1,2]. These materials have a wide absorption window from the visible to near-infrared region of the electromagnetic spectrum with the advantages of a strong absorption onset, high absorption and extinction coefficients, as well as band gaps that can be easily adjusted by changes to their composition [1,3–5]. OIHPs can transport both electrons and holes, with long charge carrier diffusion lengths that can exceed one micrometer [4]. The exciton binding energies of MAPbI<sub>3</sub> perovskite have been reported to vary from 37 to 50 meV [6–8], which is comparable to the thermal energy at ambient temperature (RT).

Many studies have found that controlling the crystallinity, homogeneity, and surface morphology of perovskites is an effective way of improving the perovskite layer to prepare materials that achieve high power conversion efficiencies in perovskite photovoltaics [1,2]. A high-quality perovskite layer can greatly reduce non-radiative recombination, which decreases both the open-circuit voltage ( $V_{oc}$ ) and carrier lifetime [9]. The reason for the reduction in non-radiative recombination is that the perovskite layer has slow ionic transport properties and good charge transport, which prevent hysteresis behavior in current-voltage

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