Slow Transformation from a One-Dimensional Crystalline Precursor to $PbCl_2$ Derived $MAPbI_3$

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Understanding the formation chemistry of metal halide perovskites is key to optimizing processing conditions and realizing enhanced optoelectronic properties. Here, we reveal the structure of the crystalline precursor in the formation of methylammonium lead iodide ($MAPbI_3$) from the single-step deposition of lead chloride and three equivalents of methylammonium iodide ($PbCl_2$ + 3MAI) (MA = CH_3NH_3). The as-spun film consists of crystalline MA_2PbI_3Cl, which is composed of one-dimensional chains of lead halide octahedra, coexisting with disordered MACl. We show that the transformation of precursor into perovskite is not favored in the presence of MACl, and thus the gradual evaporation of MACl acts as a self-regulating mechanism to slow the conversion. We propose the stable precursor phase enables dense film coverage and the slow transformation may lead to improved crystal quality. This enhanced chemical understanding is paramount for the rational control of film deposition and the fabrication of superior optoelectronic devices.