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Structure, optical studies of 2D hybrid perovskite for photovoltaic applications

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The development of solar cells based on organic molecules [hybrid perovskite solar cell] has progressed rapidly which are a good alternative for the costly silicon solar cells due to their potentially low manufacturing costs and their light weight.
For first time in 2009, hybrid perovskites were used as a solar cell. Recently, the power conversion efficiency (PCE) of lead halide perovskite (CH3NH3PbX3, X = Cl, Br, I) based thin film photovoltaic devices has enhanced from 3.8% to more than 20% in just 5 years. Therefore, hybrid perovskites could resolve the solar cell industry by matching the output of silicon cells at a lower price. Despite the exciting progress in CH3NH3PbI3 as hybrid solar cell, these perovskites readily decompose in the presence of humid air, and concerns the toxicity of Pb, which considered as the perovskite killer. It is necessary to develop alternative environmental friendly hybrid perovskite solar cells. Lead-free solid-state perovskite solar cells gain attention since 2014. Lead-free hybrid perovskites based on methyl ammonium tin iodide have been developed, exhibiting initial efficiencies of up to 6.4 %. However, Sn2+ readily oxidizes to Sn4+, which results in poor stability. This is a challenge that may be difficult to solve by using alternative alkyl ammonium groups. Another approach is to replace the Sn2+ cation with a non-toxic similar structure Bi ion which is 6p-block element and outer lone pair of 6s2 electrons having improved the stability of Bi3+ ion.
In the last few years we have designed a new series of 2D hybrid perovskites of the formula NH3(CH2)nNH3MX4 n= 3 – 9, M = Mn, Cu, Co, Bi. X = Cl, Br [1-3], in Physics department Faculty of Science Cairo University and deposited their structures in Cambridge Crystallographic Data Center CCDC Fig.1 as an example of our deposited structures. We obtained interesting physical and chemical properties regarding these 2D hybrids. Moreover, we could change the properties by tailor the hybrid structure. As we could control the distance between perovskite layers by using different organic chain lengths, or by use different metal halides. The distorted octahydron structure could be obtained by using mixed halides.
We obtained a promising results concerning photovoltaic application of 2D perovskite hybrid the primary results of the band gap energies are (1.75 eV- 2.65eV)
Hybrid perovskite based on Bi ion has longer charge carrier life time. This forms a surface layer that does not increase the recombination rate. Regarding to its stability and safety, it is highly recommended to emerge Bi alkyl ammonium as hybrid perovskite lead-free, low cost, and environmental friendly material for solar cells applications.

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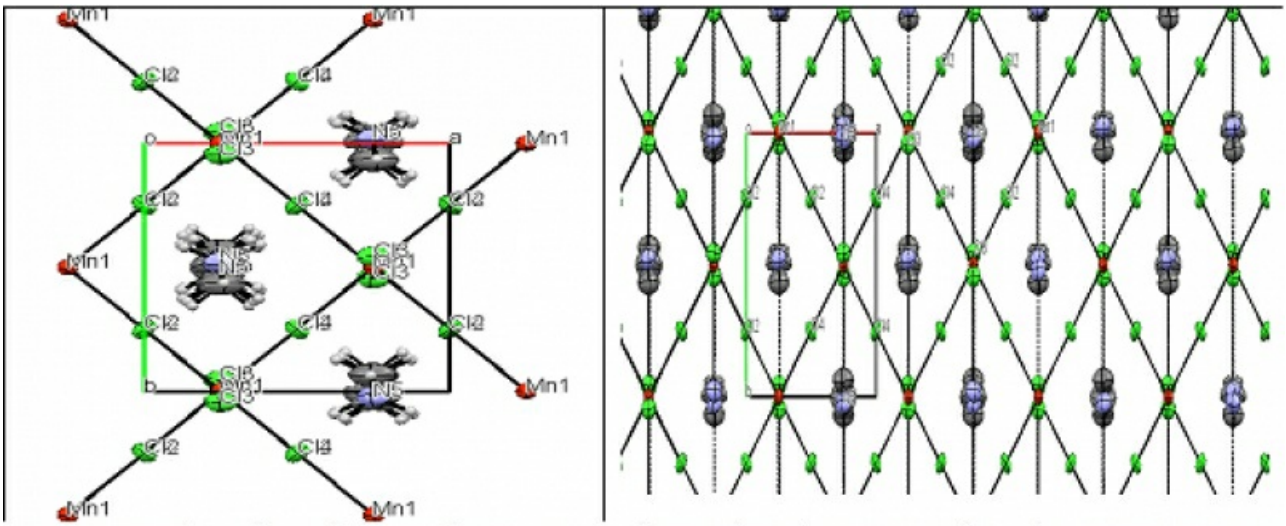

Fig.1. Unit cell and layered structure of NH3(CH2)5NH3MnCl4 (CCDC 1401387 Authors: Seham K. Abdel-Aal, A.S. Abdel-Rahman)

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