Theoretical and Physical Chemistry Institute

National Hellenic Research Foundation

Vass. Constantinou 48, Athens

LECTURE

“In quest of improving the environmental stability of hybrid halide perovskites”

Dr. Ioannis Spanopoulos

Department of Chemistry, Northwestern University, Evanston, IL 60208, United States

Thursday, February 13, 2020, 12:00

Seminar room, ground floor, NHRF

In quest of improving the environmental stability of hybrid halide perovskites

Dr. Ioannis Spanopoulos

Department of Chemistry, Northwestern University, Evanston, IL 60208, United States

Hybrid halide perovskites with general formula AMX_3 ($A = CH_3NH_3^+$, $HC(NH_2)_2^+$,Cs^+; $M = Ge^{2+}$, Sn^{2+}, Pb^{2+}; $X = Cl^-$, Br^-, I^-) is a unique family of semiconductor materials with exceptional optoelectronic properties, that have been utilized in a wide variety of important applications spanning from solid state solar cells and γ-ray detectors to photocatalysis and LEDs.[1] Although the corresponding materials are highly efficient in most of these applications, yet they are still some hindrances that must be overcome before they can reach eventually the market. These are not other than their inherent environmental instability and their composition of toxic elements (e.g. Pb).[2]

In order to address both these limitations we developed a new family of 3D perovskites, namely "hollow" perovskites, with chemical formula $(A)_{1-x}(en)_x(M)_{1-0.7x}(I)_{3-0.4x}$, (A = methylammonium (MA), formamidinium (FA); M = Sn, Pb, *en* = ethylenediammonium).[3] By adjusting the mount of *en* in the structure we were able to fine tune both the optical properties and the air stability of the corresponding compounds. Apparently, the highly "hollow" Sn and Pb based materials exhibited record stability in air.

Taking a step forward into understanding and evaluating the light and heat stability performance of hybrid halide perovskites, we synthesized two new families of 2D perovskites, by utilizing entylamine $(PA)_2(MA)_{n-1}Pb_nI_{3n+1}$ (n = 1-6, PA = $CH_3(CH_2)_4NH_3^+$, C5) and hexylamine $HA)_2(MA)_{n-1}Pb_nI_{3n+1}$ (n = 1-4, HA = $CH_3(CH_2)_5NH_3^+$, C6) as the organic spacer molecules between the inorganic slabs.[4] They were used for film assembly on various substrates, and extensive environmental stability tests were performed, evaluating their air, heat and light stability, both with and without encapsulation. Multiparameter, invaluable information was extracted from these studies, verifying for the first time that hybrid halide perovskites are inherently heat and light stable in the absence of moisture, a most critical finding for their commercialization.

References
[1] Zhao et al., *Chem. Soc. Rev.*, **2016**, 45, 655
[2] Park et al., *Nat Energy* **2016,** 1, 16152
[3] Spanopoulos et al., *J. Am. Chem. Soc.*, **2018,** 140, 5728
[4] Spanopoulos et al., *J. Am. Chem. Soc.*, **2019,** 141, 5518