On the road to nontoxic and stable perovskite solar cells

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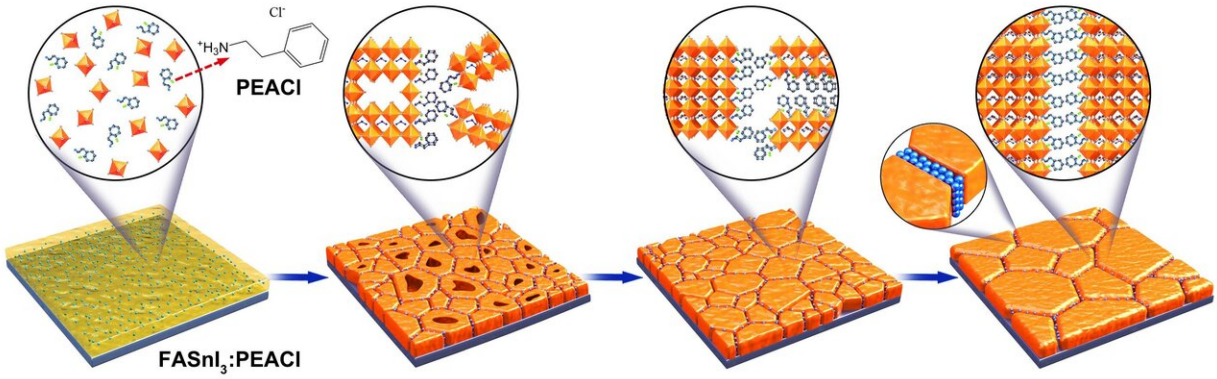

The illustration shows the changes in the structure of FASnI3:PEACl films during treatment at different temperatures. Credit: HZB/Meng Li

Halide perovskite materials show high efficiency for solar energy technologies, but this comes at a cost: The best perovskite materials incorporate toxic lead, which poses a hazard to the environment. Replacing lead with less toxic elements is difficult because lead-free perovskites have lower stability and poor efficiency. Now, an international collaboration has engineered a new hybrid perovskite material with promising efficiency and stability.

One of the best alternatives is tin. Halogenide perovskites with tin instead of lead should show excellent optical properties, but in practice,

their efficiencies are mediocre and decrease rapidly. And this rapid "aging" is their main disadvantage: The tin cations in the perovskite structure react very quickly with oxygen from the environment so that their efficiency drops.

Now, an international cooperation led by Antonio Abate, HZB, and Zhao-Kui Wang, Institute of Functional Nano & Soft Materials (FUNSOM), Soochow University, China, has achieved a breakthrough that opens up a path to nontoxic perovskite-based solar cells that provide stable performance over a long period. They used tin instead of lead, but have created a two-dimensional structure by inserting organic groups within the material, which leads to so-called 2-D Ruddlesden-Popper phases.

"We used phenylethylammonium chloride (PEACl) as an additive to the perovskite layers. Then we carried out a heat treatment while the PEACl molecules migrated into the perovskite layer. This resulted in vertically ordered stacks of two-dimensional perovskite crystals," says first author Dr. Meng Li. Li is a postdoc in Abate's group and has organised the close cooperation with the Chinese partners. At the Shanghai Synchrotron Radiation Facility (SSRF), they were able to analyze the morphology and crystal characteristics of the perovskite films precisely after different annealing treatments.

The best of these lead-free perovskite solar cells achieved an efficiency of 9.1% and high stability values, both under daytime conditions and in the dark. The PEACl molecules accumulate between the crystalline perovskite layers as a result of the heat treatment and form a barrier that prevents the tin cations from oxidising. "This work paves the way for more efficient and stable lead-free perovskite solar cells," Abate says.

More information: Meng Li et al, Tin halide perovskite films made of highly oriented 2D crystals enable more efficient and stable lead-free perovskite solar cells, *ACS Energy Letters* (2020). DOI:

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