SYNTHESIS AND INVESTIGATION OF PHENOTHIAZINE ORGANICSEMICONDUCTORS

Skirmantas Musteikis[1], Mantas Marčinskas[1], Tadas Malinauskas[1]

[1]Kaunas University of Technology, Faculty of Chemical Technology, Department of Organic Chemistry, Lithuania
skirmantas.musteikis@ktu.lt

As solar energy continues to receive increasing attention and investment, scientists are trying to develop better alternatives to the currently most widely used silicon solar cells. The production and energy costs of silicon solar cells are high, so there is a need for a new, more economical technology whose manufacturing would be cheaper, simpler, and more environmentally friendly. One of the most promising candidates is perovskite solar cells. They can be produced at lower cost using simpler fabrication methods, while the final product exhibits a similar power conversion efficiency (PCE).

For perovskite solar cells to operate efficiently, it is necessary to have layers that separate the positive and negative charge carriers generated in the perovskite light absorber. Materials that transport positive charges are called hole-transporting materials (HTMs), and they usually limit the efficiency of solar cells [1]. Currently, some of the most promising HTMs are those capable of forming a self-assembled monolayer (SAM). Solar cells employing SAM-based hole-transporting materials typically show high efficiency, low HTM consumption, and this architecture is suitable for the fabrication of tandem photovoltaic panels.

At present, lead-based perovskite technology is the most developed. This is because the use of lead results in the highest performance and stability. These solar cells are easy to fabricate and test, which is why this perovskite composition has received the most time and research attention. Although this technology is quite advanced, one major problem is immediately apparent – lead. Over time, during the use of these solar cells, a small amount of lead can leach into soil or drinking water, which would cause harm not only to the environment but also to humans.

In order to solve this problem, tin-based perovskite technology is being developed. Although this technology is relatively young and the solar cells currently achieve only about 16% PCE compared to 27% PCE for lead-based perovskites [2], the use of tin perovskites avoids lead entirely. To optimize tin-based solar cells, it is not sufficient to simply use existing hole-transporting materials, because their energy levels, geometry, and functional groups are tailored for lead-based perovskites.

Therefore, in order to enable broader and more efficient application of tin perovskites, it is important to synthesize new compounds that are compatible with the physical and chemical properties of this perovskite. In this project, a new phenothiazine compounds were synthesized, which not only could form SAM but also has additional functional groups for interaction with tin-based perovskite. With this technology, it can be expected to not only achieve higher efficiency, but also increased stability of said solar cells.

[1] [1] S. Liu, V. P. Biju, Y. Qi, W. Chen, and Z. Liu, “Recent progress in the development of high-efficiency inverted perovskite solar cells,” NPG Asia Materials, vol. 15, no. 1, May 2023, doi: 10.1038/s41427-023-00474-z.

[2] [2] Z. Xiong et al., “Homogenized chlorine distribution for >27% power conversion efficiency in perovskite solar cells,” Science, vol. 390, no. 6773, pp. 638–642, Nov. 2025, doi: 10.1126/science.adw8780.