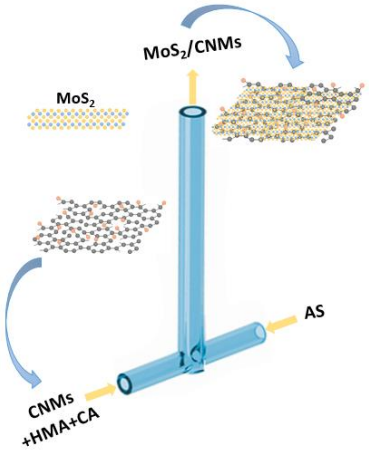
Production and properties of molybdenum disulfide/carbon nanomaterials hybrid nanostructures

*Zuzanna Bojarska, Marta Mazurkiewicz-Pawlicka, Łukasz Makowski
Faculty of Chemical and Process Engineering, Warsaw University of Technology, Warsaw, Poland
*e-mail: zuzanna.bojarska.dokt@pw.edu.pl

Keywords: molybdenum disulfide, carbon nanomaterials, photo-electrocatalysis, nanotribology

Designing and manufacturing new nanostructures with improved properties using modern techniques is a tempting prospect for nanotechnology. Molybdenum disulfide (MoS_2) is a widely used 2D nanomaterial and found various applications such as a dry lubricant, in hydrogen evolution reaction (HER) catalysis, hydrogen storage, and many others. MoS_2 can be an excellent candidate for being combined with carbon nanomaterials (CNMs) to obtain new hybrid nanostructures with outstanding properties including higher photocatalytic activity, improved tribological properties [1].

The aim of the conducted research was the preparation of hybrid nanostructures formed from MoS_2 and CNMs such as graphene oxide (GO), reduced graphene oxide (rGO), and carbon nanotubes (CNTs) in the impinging jet reactor [2],[3]. The hybrid materials were synthesized in different ratios of MoS_2:CNMs. A thorough physicochemical analysis of the obtained structures was carried out, using various analytical techniques: FTIR spectroscopy, thermogravimetric analysis (TGA), X-ray diffraction (XRD), particle size distribution (PSD), Raman spectroscopy, and scanning electron microscopy (SEM). Due to the common application of MoS_2 nanoparticles as a lubricant additive, tribological properties of the nanosuspensions of the hybrid nanostructures in 10W40 oil were tested at various temperatures. Moreover, the obtained materials were analyzed in a photo-electrochemical cell using a three-electrode configuration for further application in catalysis.



Synthesis of hybrid nanostructures MoS_2/CNMs in the impinging jet reactor is a proper method allowing to easily obtain products with desired properties, such as nanometric size, low tendency to agglomerate, narrow particle size distribution, as confirmed by PSD, FT-IR, TGA, and XRD analysis. The conducted research has shown that the addition of each carbon nanomaterials to MoS_2 reduces the friction coefficient by up to 55 %, thus improving its tribological properties. Furthermore, the CNMs also promote the charge transport and improve the photocatalytic response of MoS_2, due to their high electrical conductivity and large surface area. The method of obtaining hybrid nanostructures with the use of the impinging jet reactor is a very promising technique, that could revolutionize the engine industry and help find a cheap, metal-free, and environmentally friendly catalyst for hydrogen production.

Acknowledgments: This work was supported by the National Science Centre [No.2017/27/B/ST8/01382] and the Excellence Initiative – Research University [No.1820/11/Z01/POB5/2020]

[1] X. Li and H. Zhu, "Two-dimensional MoS2: Properties, preparation, and applications," *J. Mater.*, 2015, doi: 10.1016/j.jmat.2015.03.003.
[2] Z. Bojarska, M. Mazurkiewicz-Pawlicka, S. Gierlotka, and Ł. Makowski, "Production and properties of molybdenum disulfide/graphene oxide hybrid nanostructures for catalytic applications," *Nanomaterials*, 2020, doi: 10.3390/nano10091865.
[3] M. Wojtalik, Z. Bojarska, and Ł. Makowski, "Experimental studies on the chemical wet synthesis for obtaining high-quality MoS2 nanoparticles using impinging jet reactor," *J. Solid State Chem.*, 2020, doi: 10.1016/j.jssc.2020.121254.