ZnTe magic-sized nanoclusters: a platform for powerful chemical reduction

The global problem of the modern energy sector is caused both by the decline of the main energy sources, such as gas, oil, coal and uranium, and by environmental degradation resulting, inter alia, from the enormous emissions of greenhouse gases, in particular carbon dioxide (CO_2). This problem makes it necessary to look for solutions to reduce CO_2 concentration, which by supporting the natural process of photosynthesis will help to reduce its amount in the atmosphere. One of them is to develop a catalyst that will reduce carbon dioxide to simple chemical compounds using solar radiation. Solar-driven CO_2 reduction would provide a perfect way for the conversion of technically abundant carbon dioxide (CO_2) into practical chemical substances or fuels.

Solar-driven CO_2 reduction to CO or other valuable chemicals in solution is a extremely slow process due to unfavourable energetics of the intermediate $CO_2^{\bullet-}$ anion radical. ZnTe in principle could change this situation, because its conduction band edge is matching the energetic level of the $CO_2/CO_2^{\bullet-}$ redox couple. The photochemical stability of ZnTe however will need dramatic improvements in order to make ZnTe a useful photocatalyst.

This project aims at design, synthesis and evaluation of ZnTe in the form of “magic-sized nanoclusters”: nanoparticles with certain (small) numbers of ZnTe units are known to be much more stable than other nanoparticles and therefore may open a way to prepare ZnTe photocatalysts and electrocatalysts with sufficient stability. The project will not only deal with preparation and characterization of such nanoparticles, but also look for methods to adsorb and stabilize them on conductive and non-conductive supports. Such nanocomposites then will be evaluated in terms of electrically biased and non-biased photocatalytic chemical reduction of CO_2 (and potentially also other technically interesting entities like N_2 or metal ions).

Such an ambitious project can only be successful in an interdisciplinary approach: researchers from four different groups in Poland and Germany will be using their complementary expertise in the preparation of Zn-Chalcogenide nanoparticles, photoelectrochemical characterization of nanocomposites, analysis of surface chemistry and evaluation of electronic states at the band edge. The envisioned outcome of the project is a chemically simple and scalable (solar) photocatalyst ready to make CO_2 a useful resource for carbon-related chemistry.