Germanene derivatives synthesis and application

Zdenek Sofer
Tomas Hartman, Marco Serra, Ksenia Mosina, Jiri Sturala
Dept. of Inorganic Chemistry, University of Chemistry and Technology Prague, Technicka 5, 166 28 Prague 6, Czech Republic)
Zdenek.sofer@vscht.cz

The 14th group of elements consisting from carbon, silicon, germanium, tin and lead. In this group only carbon form thermodynamically stable layered allotrope, which is broadly studied in last two decades. On the other Silicon and germanium doesn't form layered compounds in bulk and chemical exfoliation of suitable precursors is necessary. Zintl phases of general formula AB2, where A is alkaline earth (e.g. Ca) and B is silicon/germanium exhibit layered structure containing honeycomb hexagonal motive of covalently bonded silicon / germanium atoms. By chemical etching can be calcium removed and germanene or its derivatives depending on method is formed. [1] In this work are introduced various methods for layered Zintl phase exfoliation and synthesis of germanen derivatives are discussed. The main explored methods are based on direct exfoliation of Zintl phases with alkyl halides. This method was performed under solvothermal condition as well as at room temperature with phase transfer agent. The second method is based on activation of germanane (hydrogenated form of germanene) with alkali metal using NaK liquid alloy as well as by sodium naphthalenide and subsequent reaction with alkyl halides. Scheme of reactions used for germanene functionalization are shown on Figure 1.
The properties of these materials were explored for possible application in photodetectors. The low temperature synthesis provide large area sheet of few layered germanene derivatives suitable for device fabrication. These materials shows fast response time in milsecond time scale and high sensitivity in UV-VIS-NIR region. The possible applications were explored also for use of germanene derivatives for photo-electrochemical water splitting showing excellent performance in alkaline environment and broad spectral range responsivity as well as good sensitivity for application as photo-electrochemical photodetector.

References

[1] Tomáš Hartman, Zdeněk Sofer, ACS Nano, 13 (2019) 8566.

Figures

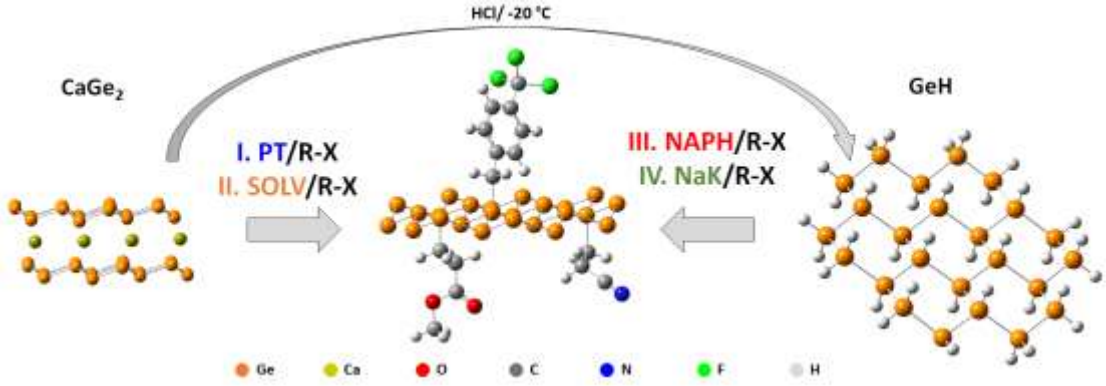

Figure 1: Schematic drawing of germanene functionalization using direct reaction of Zintl phase with alkyl halide and activation of hydrogenated germanene with alkali metal and subsequent reaction with alkyl halide.