Storing Hydrogen in graphene based materials

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Abstract

Recently, owing to the exceptional material's properties, a tremendous research interest has focused on Graphene (G). Meanwhile the production of graphene derivatives such as graphene oxide (GO) and reduced graphene oxide (rGO) has been scaled-up offering a wide range of possibilities to synthesize graphene-based functional materials for various applications. Among these, the use of G for hydrogen storage is an emerging/promising implementation considering the recent studies of the European Commission and Fuel Cells and Hydrogen Joint Undertaking [1]. Hydrogen storage is addressed as one of the key elements for the full decarbonization of our society in the medium – long term. This led to place a major focus on synthesizing materials possessing good hydrogen (H) storage properties, reaching high density for most of the potential future applications.
In this respect, G has shown to be a key material since it was demonstrated that the H storage capacity is proportional to the specific surface area of the material. Porous complex structures allowing selection of the optima porous sizes where then manufactured by our group.
However, from electrochemistry it is known that graphite (including G) shows a scarce surface reactivity. This points to the conclusion that H atoms, and molecules to a less extent, will interact with the G surface. As a matter of fact, significant H adsorption of G surfaces was demonstrated only at liquid nitrogen temperatures where up to 7 wt% may be accommodated in ultraporous G-sponges [2]. The request of room temperature working conditions pushed us to search for more suited materials. In this work we will demonstrate the possibility to synthesize G aerogels decorated with palladium with the aim to split the H molecule which can be partially adsorbed on the G surface by spillover effect.
To further increase the material H storage properties, we decorated the G flakes with Mg nanoparticles (NP) to adsorb H atoms forming Mg hydrides. Here we will show our ability to synthesize monodisperse Mg NP on the G surface, possessing dimensions in the 1nm – 5nm range.
On this nanometer scale, quantum size effects enter at play [3**]** lowering the H desorption temperature from 350°C typical of bulk Mg hydrides to 140°C with a total of 3.5%wt of adsorbed H. Further work is still needed to optimize the material performances.

References

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