Solution phase synthesis of borophene analogues

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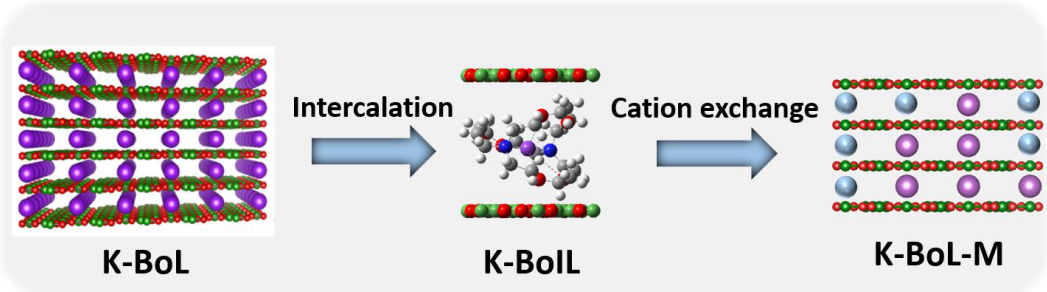
Single-atom layer materials, such as graphene, phospherene, and stanine, are usually raised unique electrochemistry properties. Borophene is reported as an allotrope of boron with two-dimensional (2D) boron sheets which has been firstly experimentally confirmed in 2015.[1] By far, the synthesis methods relied on mental substrates and usually under ultra-high vacuum systems. Due to the strict synthesis environment of borophene, it is hard to develop utilize properties practically. Our group reported potassium cations intercalated borophene-oxygen layers (BoLs) synthesized in solution phase with anisotropic conductivity.[2] The atomospheric pressure and substrate-free preparation are also adapted in other borophene analogues.

In this report, we mainly focus on a cation-exchange approach by exchanging the cations of K-BoLs with other metal cations in a solution phase. Because of the unique structure of the BoLs, single borophene-oxide layers can be obtained by peeling off the crystal stacking layers in solutions. Therefore, changing the cations between these B-O layers are theoretically feasible. Crown ethers were used for intercalating the cations of BoLs in solutions and the achieved K-BoLs intercalated with crown ethers (BoIL) were then conducting the cation exchange steps. A series of borophene analogues have been successfully synthesized and the members of the borophene analogues are enriched. The cation-exchanged BoLs are well confirmed and compared by character approaches, such as FT-IR, XRD, SEM and EDX.



1) a) Mannix, Andrew J., et al. Synthesis of borophenes: Anisotropic, two-dimensional boron polymorphs. *Science* **2015**, 350, *6267*, 1513-1516. b) Feng, Baojie et al. Experimental realization of two-dimensional boron sheets. *Nature Chem.* **2016**, 8, *6*, 563-568.

2) T. Kambe, et al. Solution Phase Mass Synthesis of 2D Atomic Layer with Hexagonal Boron Network., *J. Am. Chem. Soc.* **2019**, 141, *33*, 12984-12988.