Self-formation of chromium oxides at $CrCl_3$ nanoflake surfaces upon air exposure

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The discovery of two-dimensional (2D) magnetic ordering in chromium trihalides has attracted research attention to the study of chromium trichloride ($CrCl_3$) at the nanoscale. Its relatively weak interlayer cohesion paves the way for the isolation of $CrCl_3$ nanoflakes by mechanical exfoliation and the study of $CrCl_3$ behavior in the external environment is a crucial step for its implementation in real applications. Here, we present the results of experimental investigations on $CrCl_3$ single crystals and $CrCl_3$ nanoflakes through X-ray diffraction (XRD), Raman spectroscopy, atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), transmission electron microscopy (TEM), and energy-dispersive X-ray (EDX) elemental analysis. $CrCl_3$ nanoflakes show prominent surface oxidation at room temperature upon air exposure. Chromium oxide self-formation is proved, with the coexistence of Cr_2O_3 and $CrCl_3$ on the nanoflake surface interfaces. Different oxidized patterns are presented, with amorphous and ordered chromium oxide structures and uniquely ordered oxidized $CrCl_3$ structure. Our pivotal investigations highlight that the study of surface oxidation in $CrCl_3$ can be of great relevance in various research fields and must be considered for the implementation of $CrCl_3$ in real nanodevices. Specifically, $CrCl_3$ nanoflakes offer themselves as potential chemical precursors for the synthesis of 2D amorphous Cr_2O_3, of interest for hydrogen evolution reaction (HER).