Tuning of the topological Hall effect in A_xRhO_2 (A=K, Rb, and Cs) crystals and realizing metastable van der Waals crystalline RhO_2 magnet by Topochemical method

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Topological Hall effect, being an unconventional anomalous Hall effect, originates from the real-space Berry curvature caused by the nontrivial topological spin textures in materials. Here, we experimentally observed that the significant topological Hall conductivity σ_{xy} in antiferromagnetic $K_{0.5}RhO_2$ can reach 3.5% of ν=1 quantum conductivity below 20 K [1]. Furthermore, by adjusting the concentration of K-cation different from 0.5 in K_xRhO_2 or substituting the K cations by Rb or Cs to form $Rb_{0.5}RhO_2$ or $Cs_{0.5}RhO_2$, we observed that the topological Hall effect is much weakened or even disappeared. This evolution is attributed to the unstable ground state of the non-coplanar spin structure in K_xRhO_2 (x=0.4 and 0.6) and $Cs_{0.5}RhO_2$.

Furthermore, by the topochemical deintercalation from the $Cs_{0.55}RhO_2$ crystal, we obtain a metastable layered vdw RhO_2 crystal. Unlike the common tetragonal rutile-phase, the metastable RhO_2 possesses the 1T structure with the space group of $P\bar{3}m1$. The electrical and magnetic measurements found that it is an anti-ferromagnetic insulator with the Curie-Weiss temperature of -144 K. The first-principles calculations suggest that it is a possible spin-liquid candidate with several nearly degenerate magnetic states. Our work not only demonstrates the importance of the topochemical method in the synthesis of layered materials but also sheds light on the research fields of 4d and 5d transition metal vdw magnets.

Reference:

1. Yang-Yang Lv, Bin-Bin Zhang, Xiao Li, Dajun Lin, Shu-Hua Yao,* Ye Xiong, Jian Zhou,* Y. B. Chen,* Hongming Weng, and Yan-Feng Chen, Dramatic Tuning of the Topological Hall Effect in A_xRhO_2 (A = K, Rb, and Cs) Crystals by Electron Concentration or Cation, Adv. Funct. Mater. 2022, 2211214