

# Role of Water in Appearance of Ferromagnetism in $\text{Rb}_2\text{Ni}_3\text{S}_4$

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Layered-structure substances have attracted many researcher's interest because of their industrial applicability, for instance, as cathode materials of lithium ion cells [1, 2] and because of the novel aspects of condensed matter physics specific to the low-dimensionality in the crystal structure. In lithium ion cells, intercalation of alkali metals into or deintercalation of those from layered structure plays an important role to produce voltage and in condensed matter physics, weakness of exchange interactions among magnetic moments is supposed to derive the novelty.

Chalcogenides are known to form variable structure owing to their molecularity, and moreover, alkali metal content is supposed to govern the dimensionality of the transition element chalcogenide network [3, 4].  $\text{Rb}_2\text{Ni}_3\text{S}_4$  is one of ternary alkali nickel sulfide  $\text{A}_2\text{Ni}_3\text{S}_4$  ( $\text{A} = \text{K}, \text{Rb}, \text{and Cs}$ ) [5] with a character of two dimension. The characteristic feature of this crystal is that nickel ions constitute a Kagome lattice sandwiched by two sulfur honeycomb lattices to form  $[\text{Ni}_3\text{S}_4^2]$  infinite layers and two alkali triangular lattices separate those layers so as to be located at the center of honeycombs. This crystal is intrinsically nonmagnetic band insulator. However, by substituting a part of Co ions for Ni ions, paramagnetic moment appears for substitution up to 7%. Similarly, by immersing the specimen into water, ferromagnetic moment is known to grow depending on immersing time [6]. Paramagnetic moment appeared by substituting Co ions for Ni ions can be understood that substitution rate is small and then magnetic interaction doesn't work. However, ferromagnetic moment grown by immersing the specimen into water is difficult to understand. According to recent study, a part of crystal structure is supposed to be collapsed by water with the main structure keeping stable. In this work, we will discuss roles water perform, for example, intercalated into layered-structure or increase the surface.

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