Magnetic properties of graphene decorated with α-Fe_2O_3 nanoparticles

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We present the studies of structural and magnetic properties of graphene–Fe_2O_3 composite samples with the magnetic oxide content changing from 0 to 50%. As a starting graphene material we used graphene oxide prepared by modified Hummers method from commercially available natural graphite. Graphene–Fe_2O_3 hybrid materials were synthesized by applying a microwave solvothermal reactor process. We study the effects of graphene decoration with different amounts of magnetic oxide on the resulting magnetic order of the composite. In particular we focus on finding limits at which the magnetic properties of the composite, such as parameters of the magnetization hysteresis loop, can be varied via the changes in the Fe_2O_3 content and the type of the solvent used for the sample synthesis.

Our studies revealed that irrespective of the cleaning procedure the magnetic behavior of pure graphene samples made from graphite using Hummers method changes from diamagnetic to paramagnetic for the samples made with the use of either acetone or ethanol, respectively. The paramagnetic graphene samples contained significant concentration of magnetic moments.

For all our samples with Fe_2O_3 at $T < 110$ K we observed the superparamagnetic blocking. Moreover, due to the presence of Fe_2O_3 nanoparticles with diameter larger than 10 nm we observed the presence of transition at $T \approx 495$ K and another at $T > 600$ K. The change of the synthesis solvent changes the magnetic behavior of our samples resulting in higher effective magnetic moment for the ethanol related samples. The shape and the parameters characterizing the magnetic hysteresis loop change strongly with the change of preparation method and the amount of Fe_2O_3 in the nanocomposite. Large exchange bias is observed for all our samples indicating the significance of finite size effects of the Fe_2O_3 nanoparticles. It is therefore possible to control the magnetic properties of graphene + Fe_2O_3 composite over a wide range of values.

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