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MAGNETIC AND ELECTRIC PROPERTIES OF MAGHEMITE/PANI COMPOSITES STUDIED USING PROBABILITY DENSITY FUNCTIONS

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Abstract - A hybrid material of polyaniline doped with dodecylbenzenesulfonic acid and maghemite (γ-Fe_2O_3) was prepared by in situ polymerization in aqueous media. This hybrid material, such as pure maghemite, possesses nanometric dimensions besides joining good electrical and magnetic properties. Pure maghemite presented dimensions around 35 nm and a magnetization force around 14mN. Maghemite/PAni hybrid material still presented nanometric dimensions, associated with a reasonable electric conductivity, which is around 2700 times larger than pure maghemite, keeping ~60% of the original magnetic force. Therefore, hybrid materials are able to associate magnetic and electrical properties, being possibly useful to produce electro-magnetic polymer blends in polymeric relays.

Maghemite (γ-Fe_2O_3) presents a good stability against oxidation allied with a large magnetization capability. In addition, maghemite do not retain magnetization when not exposed to an external magnetic field, characteristic of superparamagnetic materials. This behavior is very important because avoid aggregation due magnetic attraction among particles.

In spite very attractive properties, due chemical nature differences, the preparation of polymeric composites is hard and compatibilization techniques are required. Among them, the surface modification of maghemite particles by organic compounds is very important. Therefore, in this work, the effect of immersion of maghemite particles in aniline followed by polymerization of aniline on hybrid's properties is investigated. In addition, the present work uses a probability density function (PDF) approach to represent studied properties. PDFs are used to describe the spread of experimental data around a sample average. PDFs are generally represented in terms of integrals and can be interpreted as a smoothed histogram. The commonest PDF is the normal distribution, frequently used for computation of confidence limits of experimental data [2]. PDFs must satisfy the following requirements: PDFs are non-negative everywhere; the area bounded by PDFs is equal to 1; the probability for a random value to be within the interval (α, β) is equal to the area bounded by the curve within this interval, as shown in Figure 1. Therefore pointing a better understanding of produced materials, electrical resistivity and magnetization force tests were performed and probability distribution functions were used to describe the spread of experimental data [2].

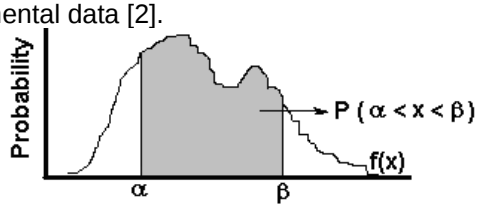

Figure 1: Probability Density Function.

Tested materials presented considerable magnetic force. Pure maghemite possesses a magnetic force equal to $14.31^{+0.55}_{-0.64}$ mN while hybrid materials containing 25wt% and 8wt% of γ-Fe_2O_3 presented magnetic force equal to $8.00^{+0.21}_{-0.14}$ mN and $6.00^{+0.14}_{-0.13}$ mN, respectively. Thus, PAni-25 kept 56% of magnetic force while PAni-8 was able to retain 42% of the magnetic force, both in comparison with pure maghemite.

Electric resistivity tests also presented interesting results. Pure maghemite presents a large electric resistivity equal to $1.916^{+0,059}_{-0,140}$ x10^6Ω.cm. On the other hand, even the smallest amount of PAni was able to produce a very expressive decrease of the surface resistivity. Hybrids materials containing 25wt% and 8wt% presented surface resistivity equal to $1.095^{+0,115}_{-0,312}$ x10^3Ω.cm and $7.19^{+0,03}_{-0,06}$ x10^2Ω.cm, respectively. These results are very interesting once they prove an increase of the electrical conductivity equal to ~1800 and ~2700 times in the hybrids materials containing lower and higher amounts of PAni, demonstrating that modified materials are able to congregate reasonably electric and magnetic properties of pure materials.

Present work deals with magnetic-conducting nanomaterials prepared by a cheap and environmentally friendly in-situ technique. Hybrid materials were able to congregate electrical and magnetic properties of original materials, being possibly advantageous in polymeric blends able to produce conductive-magnetic films applicable in polymeric relays field.

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