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**Direct Observation of Quincke Rotation of Disk Shaped Polymer Composites in a
Uniform DC Electric Field**

Miklós Antal¹, Genóva Filipcsei^{1,2} and Miklós Zrínyi¹

¹Department of Physical Chemistry and Material Sciences, Budapest University of
Technology and Economics,

²Materials Structure and Modeling Research Group of HAS-BME, H-1521 Budapest
HUNGARY, Phone: 36-1-4633229, Fax: 36-1 4633767, E-mail: zrinyi@mail.bme.hu

Abstract

Experimental evidence of DC electric field induced Quincke rotation of polymer composites has been shown for the first time. We have found that angular velocity of disk-shaped hematite loaded gelatin composites immersed in linseed oil scales with the square of the uniform electric field intensity.

Keywords: Smart materials, oxides, polymers, polymer-matrix composites, electrical properties

INTRODUCTION

In 1896 G. Quincke observed that some solid particles (e.g.: glass, aragonite, sulphur, topaz, tourmaline) can spontaneously rotate in certain media (ether, carbon disulphide, benzyl, and different oils), if a strong uniform electric field is applied [1-4].

In most cases the rotating particles are made of inorganic materials that are difficult to fabricate [3,5]. For solid particles Quincke rotation is observed when the charge relaxation time of the solid particles is larger than that of the medium [2].

The main purpose of this preliminary study is to develop polymer composites with controllable shape and size in order to utilize Quincke rotation for micro motor applications.

EXPERIMENTAL PART

Hematite particles with 0.1 μm (short axis) and 0.6 μm (long axis) were dispersed in gelatin solutions with variable concentration from 10 to 20 $\text{m}\%$. The mass ratio of the filler to the dry polymer was varied between 0.36 and 10.4. The mixture was poured into a cylindrical mould and dried carefully at ambient temperature. Samples with a diameter of 240 μm and height of 80 μm were obtained. Several disks with a wide range of hematite/gelatin ratio were fabricated in order to find an ideal composition for Quincke rotation.

To study the Quincke rotation a polymer disk was immersed in linseed oil between two parallel nickel wires separated by 2 mm . A uniform electric field was supplied by a high voltage DC power supply (Technoorg Linda, Hungary). The electric field strength was calculated as the ratio of voltage and gap distance.

The rotation of the disk was followed by an optical microscope (JENAMED Variant, Germany) equipped with a CCD camera (Sanyo, Japan). To visualize the rotation and determine the angular frequency, a visible dot close to the edge of the disk was used. The angular frequency of the rotation was determined by recording the spinning motion of the disk. All experiments were carried out at room temperature.

Fig.1.a shows the top view of the rotating polymer disk.

RESULTS

We have found that the intensity of Quincke rotation strongly depends on the hematite/gelatin mass ratio. The highest rotational speed in uniform DC electric field was observed at 2.67 mass ratio. It is worth mentioning that unloaded gelatin disks display no Quincke rotation. Fig.1.b shows the dependence of the angular frequency of the rotating disk on the DC electric field intensity. It can be seen that with increasing the electric field strength, the angular frequency increases. Careful analysis of experimental data based on a nonlinear least squares method revealed a quadratic dependence. It was found that the Quincke rotation occurs at $E_{cr} = 0.83 \cdot 10^6 \text{ V/m}$ field intensity and the angular frequency scales with the square of electric field strength.

Figure 1

Further experiments and analysis is needed in order to provide a better understanding of the phenomenon observed by us for the first time.

CONCLUSION

We have presented the first direct observation of DC electric field induced rotation of a disk shaped polymer composite. We showed that the speed of rotation scales with the square of the applied field. The rotating disk acts like a micro sized motor with tunable angular frequency.

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Figure captions:

Fig.1.: Quincke rotation of hematite loaded gelatin composite. The hematite/gelatin mass ratio is 2.67.

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Figure 1

