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Study of gas adsorption on biphasic nanostructured surfaces

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Abstract

This work has carried out on grafted nanoparticles oxide silica to determine the possible existence of "nanoeffect". The textural properties and heterogeneity of surface of the samples were studied at the interface solid-gas. The Geometric properties were discussed in terms of the surface area while the energy properties were discussed in terms of the reactive sites of the surface.In the framework of this study, firstly, the sample was used in the non-grafted state and then in the grafted state using a hydrophilic molecule and a hydrophobic molecule. Several techniques have been used: Infrared spectroscopy, X ray diffraction, the point by point volumetric technique, which enable us to study the interactions between the adsorbate and the solid surface. Finally we have determined the size and electro thermal mobility using zestasizer (Nano ZS). The results obtained show that there are two types of groups silanols and siloxanes on the silica OX5 giving a composite hydrophilic-hydrophobic. This character causes a singular behavior in adsorptive material, the presence of hydrophilic groups, strongly polarized, and is detected by infrared spectroscopy. These groups cause significant differences depending on the polarizability of the probe molecules, and the adsorption of argon shows no heterogeneity of the surface, while nitrogen is adsorbed on the polar sites at low relative pressure, While the volumetric continues to adsorption of argon and nitrogen on combustion silica to obtain and to highlight sites of high energy and polar surface sites. The combustion silica which has been used as adsorbent in this study has an amorphous surface, virtually free of impurities indicates that the sample is not micro porous and grafting of the molecules makes a decrease in high energy sites or to a relative increase in surface low energy.

Keywords: Surface energy, adsorption, nanomaterials, porous materials, hydrophilic-hydrophobic interactions

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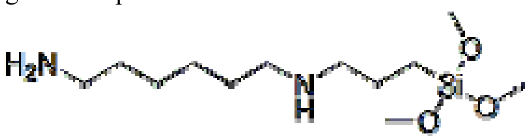
1. Introduction

Since the late of twentieth century, science has changed considerably with the conscience of the potential control of the "infinitely small» [1]. Today, the trend is toward miniaturization and the materials are not an exception either. Before the development prospects offered by the object nanometer, nanoscience and nanotechnology areas are now booming. The applications are numerous: both in medicine (in 2007 constituting 24.1% of projects), as in the industrial sector with information technology and materials, through the understanding of certain scientific phenomena still unexplained and environment [2]. A total turnover worldwide is estimated at one trillion by 2015. For nanoparticles, the proportion of atoms in direct contact with the external environment is more important than for larger particles. Reported to the mass of solid, the superficial reactivity is then decreases. The activity of the surface of nanoparticles is their main advantage, since for the same reactivity; the amount of material is less. Therefore, they have an important economic value. However, miniaturization of materials can also change their surface reactivity, and their behavior towards the external environment. Indeed, the passage from the micrometer scale to the nanoscale (billionth of a meter) changes the physical [3,4]. and chemical properties of materials [5]. A current scientific challenge is to achieve better knowledge of these nanoparticles in order to limit the risks that could cause, especially in medicine field. Silica, $SiCl_4 + 2H_2 + O_2 \rightarrow SiO_2 + 4HCl$ .SiO_2 exists in many forms, from natural or synthetic origin. In natural state, it is most frequently encountered in its crystalline quartz, a constituent of many rocks: sedimentary, metamorphic or igneous. The main features of its synthesis products (grain size, specific surface, ...) are modulated by the preparation conditions (combustion, precipitation)] Applications of synthetic silica are extremely large, they cover a wide range, ranging from strengthening of polymers and the synthesis of heat shields covering the spacecraft. We showed for combustion silica , used as a thickener for liquids, catalyst support, raw materials of high purity silicate load polymers to improve mechanical properties, thermal or electrical insulation. All these applications involve far microparticles. For economic reasons, and new uses, it is believed to gradually replace them with nanoparticles. As part of this work, it was "the study of gas adsorption on nanostructured surfaces biphasic, the objective of this study was to highlight the influence of the grafting of organic molecules on the properties Textural and surface energy properties of fumed silica OX 50 in solid / gas interface. Geometric properties are discussed in terms of surface area and energy properties in terms of reactive sites of the surface.

2. Materials and methods

2. 1. Sample preparation and characteristics

Aerosil OX_{50} silica produced by Degussa is obtained by flame hydrolysis of silicon tetrachloride $SiCl_4$ in the presence of hydrogen and oxygen at about 1000 °C; The solids from this combustion are composed of strings of grains, the grain size can be modulated by the conditions of combustion between 5 and 50 nm. In this study, the same sample is used, first ungrafted and then grafted with a hydrophilic molecule and a hydrophobic molecule. The synthesis of grafted samples was performed in Mulhouse (France).
The grafted molecules are organic compounds whose formula is:



$C_{12}H_{30}N_2O_3Si$ (95 %) : NH_2=N-(6-aminohexyl) aminopropyl (Si + hydrophilic NH_2)

$C_{18}H_{37}Cl_3Si$ (92%) : CH_3= n-Octadecyltrichlorosilane (Si + hydrophobic CH_3)