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Surface modification of sepiolite particles with polyurethane and polyvinyl alcohol

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ABSTRACT

Sepiolite is a clay mineral that has many industrial applications due to its advantageous properties such as white color, low specific gravity, high absorption capacity, chemical composition and low thermal conductivity. In this study, the effect of the addition of polymers, polyvinyl-alcohol and polyurethane, on the rheological properties of the sepiolite dispersions have been investigated. The rheological parameters of clay suspensions can be used to examine particle–particle interactions. The polymers that have been added to the clay suspensions interact with clay particles, depending on their ionic or non-ionic character. Firstly, the sepiolite dispersions were characterized by the rheological properties, mineral structure and content. Then the effect of the polymers on the flow, structural, and surface properties of sepiolite dispersions was investigated by rheological, electrokinetical, and scanning electron microscopy (SEM) measurements. The measurements showed that polymer molecules bind on the surface of sepiolite particles and changed the flow properties of the dispersions as stable dispersions at some certain concentrations. It is also determined that PU polymer covered the surface of the sepiolite faster than PVA, but the coverage of the PVA was much more smoothly. The thermal properties of the sepiolite improved with PVA more than PU, as a result of the homogenous surface coverage.

1. Introduction

Sepiolite, formerly known as Meerschaum (sea froth), is a non-swelling, lightweight, porous clay with a large specific surface area. Unlike other clays, the individual particles of sepiolite have a needle-like morphology. Sepiolite is phyllosilicate that contains a continuous two-dimensional tetrahedral sheet; however, it differs from other layer silicates in that it lacks continuous octahedral sheets. Its structure can be considered to contain ribbons of a 2:1 phyllosilicate structure, each ribbon being linked to the next inversion of SiO_4 tetrahedra along a set of Si—O bonds. Thus, tetrahedral apices point in opposite directions in adjacent ribbons [1,2]. This chain-like structure produces needle-like particles instead of plate-like particles common for other clays. The high surface area and porosity, as well as the unusual particle shape of this clay account for its outstanding sorption capacity, colloidal and catalytic properties that make it a valuable material for a wide range of applications.

Clay minerals find almost innumerable applications, and the diversity of uses is still increasing. Sepiolite minerals are among the most interesting members of the family of clay minerals because of their characteristic properties. Moreover, the gel-like structure in water, plasticity, rheological and electrokinetic properties of these minerals are all of great interest. The industrial application of sepiolite-water systems is very widespread in sorptive, catalytic and rheologic applications. Today, they are used in different branches of industry such as in drilling fluids, dyes, pharmaceuticals, paper, cement, detergent and cleansing materials making, agriculture and ceramics [3,4]. The reason is the large variety of clays and clay minerals and the ease with which these materials are modified. The surface of the sepiolite particles can be modified by adsorption, ion exchange with inorganic cations and cationic complexes, ion exchange with organic cations, binding of inorganic and organic anions, mainly at the edges, grafting of organic compounds, reaction with acids, pillaring by different types of poly hydroxo metal [5,6].

In this study, the rheological properties of sepiolite dispersion were determined and then, the effects of PVA and PU on the rheological properties of the sepiolite samples at different concentrations were investigated to evaluate the results by considering the interaction modes between the particles and polymer molecules. FTIR measurements provided reliable data to document whether PVA or PU molecules attaching onto the clay minerals or not. The electrokinetical measurements were done to determine the change of the surface properties of sepiolite samples by addition of PVA and PU. Finally, the effects of the polymers on the thermal properties of the sepiolite were investigated by DT-TGA methods.

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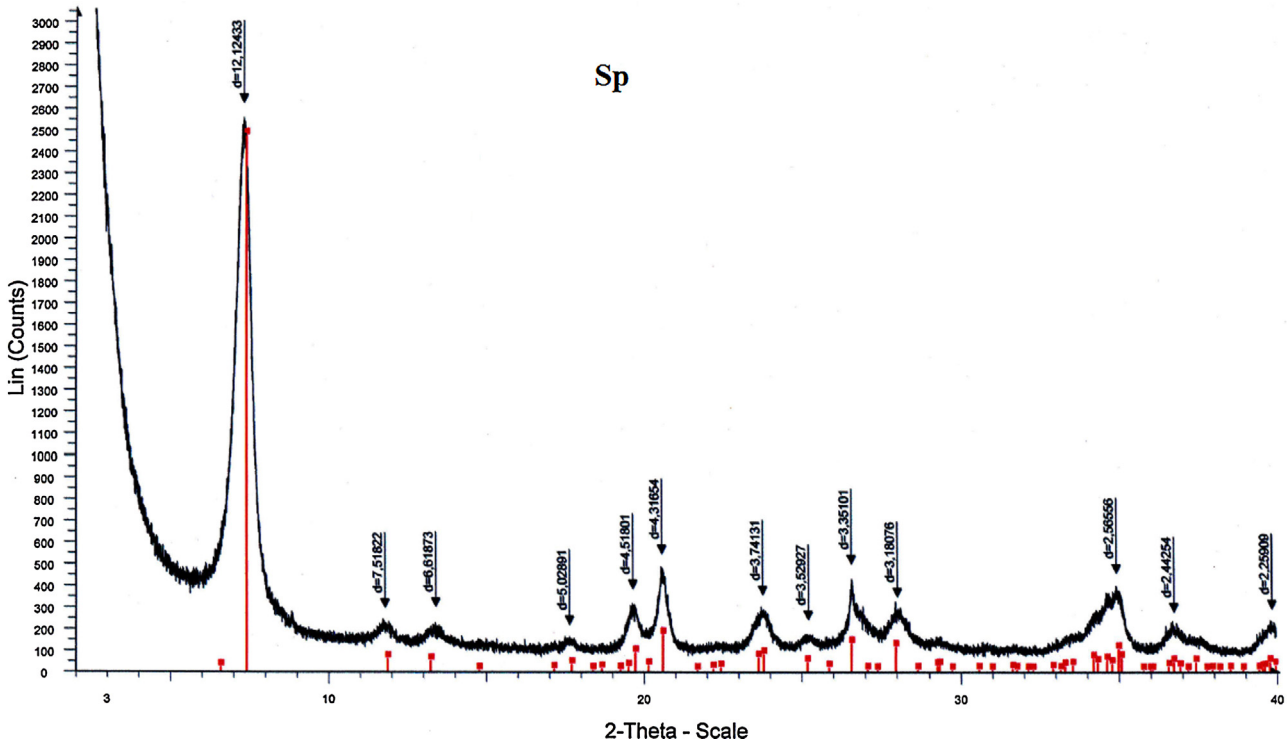

Fig. 1. The XRD pattern of sepiolite.

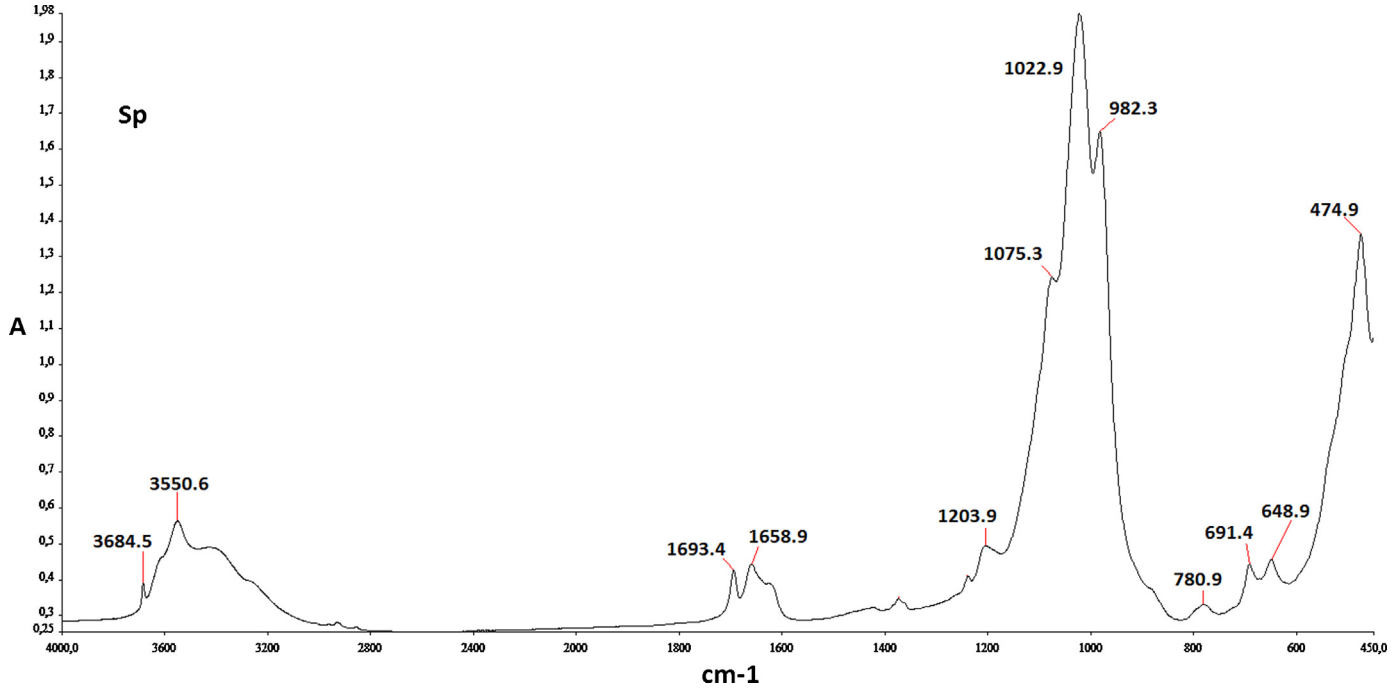

Fig. 2. FTIR spectra of sepiolite.

2. Experimental study

2.1. Materials

Sepiolite sample (Sp) was obtained from Eskişehir, Turkey. The XRD (model X-ray diffractometer) and IR (Pelkin Elmer Spectrum 100 FTIR spectrophotometer) instruments were used to identify clay mineral type.

Polyurethane (PU) (C_8H_{18}, 88 wt.% solution in H_2O) from Aldrich Chemical Co., were used as received.

Polyvinyl alcohol (Sigma, Germany) is a mixture of synthetic polymers produced by the polymerization of vinyl acetate and partial hydrolysis of the resulting polymer's acetate groups [—(CH_2CHOH)$_n$—($CHOCOCH_3$)$_m$—]. Chemical and physical properties of commercial polyvinyl alcohol (PVA) varied depending on its degree of polymerization and degree of hydrolysis. The degree