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Talc, a multi-purpose filler: A review of talc's features and improvement methods of its efficiency

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ABSTRACT

The fillers are fine particles mainly produced from the natural minerals and used in various industries for different purposes. Talc is a hydrophobic filler and chemically inert; therefore, it is used in many industries. This is very important in the paper industry. In fact, compared to other fillers used in the industry, talc improves the quality of the final paper product and also, reduces the environmental problems of paper making factories. This provides many economic advantages for papermakers and causes to have more focus on the processes which improved the filler efficiency. Therefore, understanding the characteristics of talc and its improvement methods is an inevitable necessity.

INTRODUCTION

Talc is a hydrated magnesium covered silica with the chemical formula of $Mg_3Si_4O_{10}(OH)_2$[12]. Talc can be considered inorganic polymer based on two basic ‘‘monomer" structures – the silica tetrahedron and the magnesia octahedral. These minerals contain a continuous octahedral layer with the joined octahedral tied on a triangular side. This layer is bound on both sides by a continuous silica layer [10, 34].

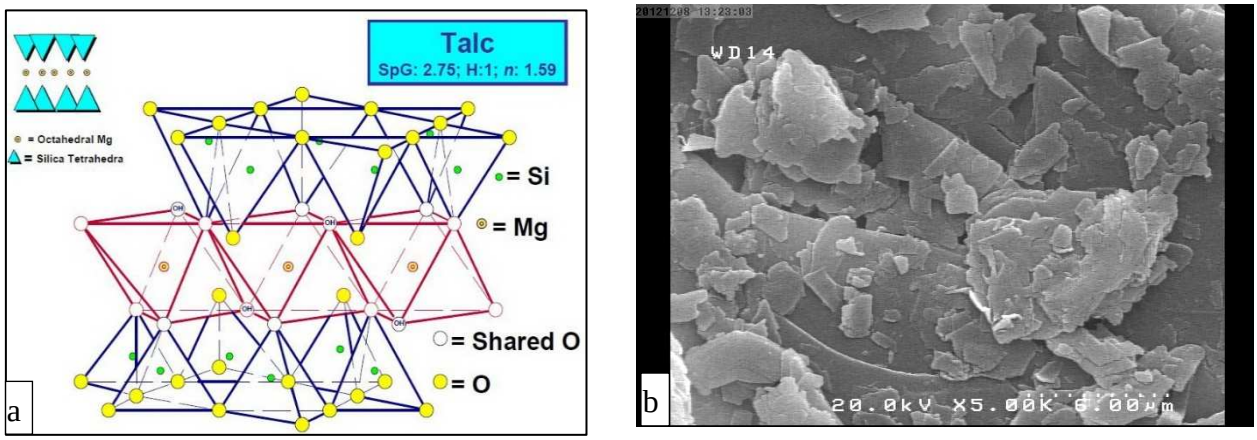

Figure 1.(a) Schematic image of talc structure and (b) SEM image of its particles

It is a white, apple green, gray powder with luster pearly or greasy, and a Mohs hardness of 1-1.5 which has low electrical conductivity and high resistance to acid, alkali and heat.The crystal habit of talc corresponds to flattened tabularcrystals with a hexagonal cross-section (Figure 1). The hydroxyl groups normally are internal to the

magnesium layer and are not accessible to water except at the edges of the silicate sheet. Thus, talc powder chemically is a hydrophobic material that easily blends and disperses with organic media including polymers but is not easily dispersed in aqueous solvents [20]. Therefore, talc is widely used as a fine powder in several industrial products such as paper, paints, rubbers, polymers, ceramics, putties, etc. [6,7,9, 13, 14,21,23, 24, 30, 33].

Paper industry is one of the greatest industrial consumers of water in the world and its effluent is one of the main sources of environmental pollutant. In the wastewater treatment, several purposes are followed that the removal of toxic heavy metal ions and bacteria is of great importance from anenvironmental viewpoint [41]. In this regard, talc can particularly improve the performance of the biological effluent treatment units. Talc particles can balance the bacteria flocs and accelerate their sedimentation. The talc addition leads to higher quality discharging and lacking bacteria up to 0%.Unlike most chemicals used for effluent treatment, such as chlorine or aluminum salts,Talc is a natural and environmentally friendly mineral additive and since it is inert, it will keep the fertilizing value of sewage sludge. In addition, in the industry,which is also the greatest consumer of talc,the filleris used for 3 other purposes [12]:

- **Filler**: Talc gives good softness, porosity and opacity to final paper, besides cost reduction. Because of its plate-shaped particles, which givesgood smoothness to the paper, it is a good filler for rotogravure printing papers.
- **Formulation of coating materials**: Since it gives good smoothness to the surface, it prepares good opacity for coating and due to its brightness, it also helps to control the coating gloss.
- **Controlling the pitch**: Talc prevents the accumulation and deposition of stickies on the felts and calendars by absorbing them into its layered structure and unlike the pitch control chemicals that are contaminated the process water, it will remove with pulp and thereby,it enables the papermaker to work easier in the closed system.

Though talc has been a quality filler mainly available in Asia Pacific, a scanty research has been carried out on its modification [39] but recently more attention was paid to evaluate the possible changes of its main properties during processing; because some of its intrinsic characteristics could modify by specific treatmentsand thereby,it could improve its efficiency.Therefore, the most important and functional treatments were studied in this research.

Flotation is one of the treatments. This method is used to remove iron bearing minerals (i.e. talc impurities) and during it, talc slurry is added to flotation device with other chemicals (such as oleic acid as anionic collector and sodium hexametaphosphate as depressant). The frother is used to increase the efficiency of this method. Various factors control the flotation of talc including particle size, pH,collector dosage, depressant dosage, pulp density andfrother dosage. Due to flotation and removing the metal compounds from the talc structure, its purity will be increased and thus, the filler brightness will bealso improved [3, 4, 5, 8, 15, 17, 26].

The mechanical grinding process is another method which is used to change the filler properties. In this method, a wide range of mills can be used such as Air Classified Mill, Vibrating Mill, Planetary Ball Mill, etc. Due to grinding, the decrease of mean particle sizeand the increase of specificsurface area of the filler will occur. This has a significant influence on the wettability of the material and will improve its optical properties [1, 2, 11, 16, 19, 25, 31, 37, 38].

Perhaps it can be said thatthe surface modification isthe most important treatment of talc filler. In fact, it is a process that during it, the particles' surface is coated by one or more chemicals. The main method in this field, is the modification by using cationic polymers. In this method, a cationic polymer such as cationic polyacrylamide (CPAM) is added to talc slurry and thereby, a positive charge is applied to the particles and thus, they stick together and form flocs. It is extremely important, especially in the paper industry. Because with this method, besides the retention of fillers in the paper will be increased, the filler abilityof sticky contaminants trapping will be enhanced too, especially when deinked pulp is used as cellulosic source (Figure 2).Therefore, it reduces the fiber and filler loss, and pollution load of the disposal system and so, the reduction of production costs is obtained by reducing the costs associated with wastewater treatment [18, 27, 28, 29, 32, 35, 36, 39].

The coating of talc particles was also performed by other chemicalssuch as $Al_2O_3.3H_2O$,P_2O_5,Phthalimide, silica, carboxymethyl cellulose (CMC), etc. It was found that the surface of talc particles was modified by using coating method andtheir wettability was also increased which has a positive influence ontheir combinative affinity withthe surrounding particles [6, 22, 30, 40].

Figure 2. SEM image of talc containing CPAM in the deinked paper

There are another methods including combination of mentioned methods. For example, lasmarias et al [29] firstly ground talc by Air Classified Mill up to the particle size less than 10µ and then,a cationic compound was added to it. It influences on the hydrophobicity of talc particles and makes it hydrophilic.

RESULTS

Talc is a filler used widely in various industries. This makes it necessary to identify its chemical structure. Since the filler efficiency is high in the removal of the stickies especially from the effluent of paper factories and this is environmentally extremely important. Therefore, the chemical modification of the filler can improve its properties and thus, studying the modification methods can be useful for the industries.

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