PROPERTIES OF FILLERS AND REINFORCING FIBERS

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Fillers have always played an important role in the plastics industry. Filled polymers form a specific class of composites, which are tending to replace many traditional materials. Various kinds of organic fillers are used. The experimental study of such nonconventional organic and inorganic fillers obtained from agricultural waste is presented to modify the properties of thermoplastics, such as PVC, HDPE, LDPE, and ABS. The properties obtained by using these fillers alone and in combinations show very interesting results, which are tabulated. The use of organic fillers should help lower the cost of many plastic products required in the building and agricultural industries.

INTRODUCTION

The growing industrial activities create a continuous demand for improved materials which satisfy the increasingly stringent requirements, such as higher strength, modulus, thermal and electrical conductivity, heat distortion temperature, lower coefficient of thermal expansion coefficients, reduced costs, etc. These requirements often involve a combination of many properties which are difficult to attain. This may dictate the use of a composite material whose constituents will act synergistically to solve the needs of application.

Fillers have always played an important role in the plastics industry [1]. Filled polymers form a class of composites, which tend to replace many traditional materials. The original purpose of using fillers was to lower the cost of molding compounds. Nowadays, it is established that fillers are important for selective modification of properties. Various kinds of fillers are used and all of them fit well with the required application.

Fillers are solid additives, differing from matrices of plastics in composition and structure, which are added to polymers to increase bulk or improve properties. Fillers are generally inorganic and less frequently organic.

Inorganic fillers are an important class of fillers in the plastics industry and various types of inorganic fillers are already being used commercially to modify the properties of compounds of the plastics. The inorganic fillers being used are calcium carbonate, various clays, barium sulphate, fine powders of some metals, aluminum trihydrate, aluminum hydrate, etc. Thermoplastics and thermoset industries have been using these fillers traditionally. These inorganic fillers have some limitations of use due to greater specific gravity and lower compatibility with the polymers. The organic fillers are characterized by their low specific gravity. However, very little data are available on the use of these organic fillers in thermoplastics. The use of the fillers, which can be easily obtained from agricultural waste, should help lower the cost of many plastic products, particularly in the building and agricultural industry.


Work is therefore undertaken to use organic fillers like starches (obtainable from waste seeds), coconut shell powder, egg shell powder, tea-leaves waste, etc. in thermoplastics. PVC, which is a major consumer resin in thermoplastics (TP) \[2, 3\], was selected for most of the study. Some work was also carried out to study the effect of these fillers on other TP, such as HDPE, LDPE, ABS, etc.

**Organic Fillers**

1) **Starches.** Starches from corn, tapioca, sago, rice, potato, etc. have been recently proposed as fillers for plastics.

Corn starch exhibits the polygonal type of starch granules, which are more uniform in size, ranging from 15 to 25 \(\mu\)m.

Granules of tapioca starch are similar to those of corn and their size ranges from 5 to 35 \(\mu\)m. The largest are usually from 25 to 35 \(\mu\)m and the smallest from 5 to 15 \(\mu\)m. The granules are round with a flat surface on one side containing a conical pit, which extends to a well-defined excentric hilum. Some granules are almost spherical.

Starch is a reserve substance of many organisms, most belonging to the kingdom of plants. It consists of spherical or ellipsoidal grains ranging in particle size from 3 to 100 nm. Starch is stored in the form of granules and their structure is intimately associated with its development in the living cell. Starches are insoluble in cold water and alcohol but form a jelly with hot water. The specific gravity is in the range of 1.499 to 1.513.

2) **Coconut Shell Powder.** The powder is obtained from ground coconut shells. It consists of broken tracheids (tubular vessels of narrow bore), which are heavily lignified. In comparison with wood flour, coconut shell flour has a lower specific volume. The shape of the particles varies essentially from spherical to thin sliced tracheids.

Although materials filled with coconut shell powder are of poor colour, they have good electrical insulation properties, improved flow characteristics, and a blackish-brown glossy surface finish, which resembles shisam. Lignin, which comes out through narrow tracheids, serves as plasticizer to some extent.

If treated with some resinous material and then blended with resin-like PVC, coconut shell powder has better flow properties and can be processed successfully either by extrusion or injection molding. The literature regarding the use of coconut shell powder as a filler material for thermoplastics is not available. An ideal thermoplastic resin for loading of coconut shell powder is extrusion grade PVC. Attempts to load other resins such as LDPE, HDPE, and ABS have been also made, but their flow properties were poor.

Treated with suitable materials, processing of coconut shell powder shows better dispersion with resin.

3) **Wood Flour.** Wood flour is widely used in thermoset plastics, because of its low cost, incorporation, good surface finish and satisfactory physical properties. It is a fine saw dust of uniform size free from small chips and is obtained from waste during machining of wood. Wood flour should be free, as far as possible, from organic soluble constituents, i.e., it should not contain dirty bark and knots. Generally, the best suited flour is obtained from soft woods, like pine, beech, oak, etc. The particle size should be sufficiently small to give a smooth surface appearance of moldings. The recommended size is 80 to 50 mesh. Wood flour will decrease shrinkage during molding and improve the impact strength of the molded articles.

4) **Walnut Shell Flour.** This is a cellulose filler, which contains a high proportion of lignin and wax called cutin, which is not present in wood. A typical analysis of hard nut shells would give 59 to 60% cellulose, 30 to 34% lignin resin, 5 to 6% cutin wax, and 8 to 9% pentocin.

Because of the high content of lignin resin and cutin wax, which makes the flour virtually nonabsorbent for water, the filler shows good gloss and improved flow properties in the compound. Lignin itself being resinous helps improve the electrical insulation properties. The presence of cutin in walnut shell flour ensures good moisture resistance and hence high dielectric strength.

The original shell itself is a fairly dense, nonfibrous mass and when ground produces spheroidal nonfibrous particles. Commercially, a particle size of about 40 mesh is used. It can contribute less to the tensile