4 Fillers for papermaking

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4.1 Introduction

The incorporation of fillers in paper has been common practice for many years. Though the term ‘filler’ is somewhat uncomplimentary, this group of predominately inorganic materials has become a very essential component of many grades of paper. The original purpose of adding filler to the paper matrix was to lower furnish costs with the amount of filler limited only by strength considerations. Today the principal need for fillers is to impart specific quality improvements to the sheet. Depending on the performance characteristics of the fillers and the amount added to the paper, these products can improve the optical, physical, and aesthetic properties of the finished sheet. Today the practice of utilizing fillers is based on choosing materials which will provide both cost and quality improvements. The conversion to alkaline papermaking in North America has emphasized this approach, where fillers designed to add value to the paper are routinely used. This trend has been confirmed by the rapid growth in the tonnage of valued-added speciality fillers purchased by paper mills.

4.2 Functions of fillers

Fillers are added to paper in various percentages, typically between 10–20%, to perform many different functions. The choice of which filler or blend of fillers to use depends upon the specific properties desired. While fillers are used in many different grades of paper they find their greatest utility in printing and writing grade papers. Fillers can contribute the following properties to paper:

- improve sheet formation by filling in the void areas around fiber crossings
- provide a smoother surface
- increase opacity and brightness
- provide enhanced printability due to a number of reasons such as (i) a smoother, more uniform surface, (ii) less show through caused by increased opacity, and (iii) better ink receptivity reducing ink penetration, wicking, and strike through
- improve dimensional stability (most fillers are not hygroscopic like fibers)
- provide cost savings by replacing higher cost fiber with lower cost fillers

The properties exhibited by a filler in paper are mainly dependent on two
factors: (i) the characteristics of the filler and (ii) the way in which it is used. Filler characteristics of importance are refractive index, particle morphology, particle size and distribution of size, specific surface area, brightness/whiteness, particle charge (zeta potential), and abrasiveness. The manner in which fillers are incorporated into paper varies considerably from machine to machine. The pulp species, type and amount of refining, wet-end furnish components such as starch, retention aids, and sizing agents, and addition point of the fillers can cause the filler to behave quite differently depending on furnish conditions. Certainly the amount of filler incorporated into the sheet will have a dramatic impact on sheet properties. More detailed information on the important characteristics of fillers is presented below, followed by the specific properties of various filler materials, and some comparative data showing the performance of fillers in paper.

4.3 Characteristics of fillers

As mentioned above, refractive index, particle morphology, particle size and distribution of size, specific surface area, brightness/whiteness, particle charge, and abrasiveness are some of the more important characteristics of fillers which have a great impact on the optical and physical behavior of the paper.

4.3.1 Refractive index

Refractive index is a fundamental property of a filler which is governed by its chemical composition and molecular structure. Atomic structure has a direct influence upon light scattering (opacity), because light entering the filler particle is bent and/or refracted from its normal path many times over within the particle rather than transmitted through it. The greater the refractive index of a filler, the greater the amount of reflected light which increases the opacity of the paper.

The refractive indices of anatase and rutile titanium dioxide are 2.55 and 2.76 respectively. All other commonly used fillers have refractive indices much lower than titanium dioxide: calcium carbonate (1.58–1.66), calcined clay (1.62), styrene-based fillers (1.58–1.59), aluminum trihydrate (1.57), talc (1.57), hydrous filler clays (1.56), sodium silicate (1.55), and silica (1.45). As a reference, the refraction index of cellulose is 1.55, of starch is approximately 1.49, and of air is 1.00.

4.3.2 Particle morphology

Particle morphology or shape has been shown to be a significant characteristic of fillers. The shape of the particles will influence the way light is scattered. This in turn will affect the optical performance of the filler in paper.