Progress in Materials Science 83 (2016) 574–594

Contents lists available at ScienceDirect

Progress in Materials Science

journal homepage: www.elsevier.com/locate/pmatsci

# Cellulosic fines: Properties and effects

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A R T I C L E I N F O

*Article history:*
Received 8 July 2016
Accepted 23 July 2016
Available online 25 July 2016

*Keywords:*
Fines
Paper properties
Mechanical pulp
Chemical pulp

A B S T R A C T

Any cellulosic pulp consists of particles of different dimensions. When trying to understand and control its properties, it is important to consider not only the bulk amount of long fibres, but also the material known as ‘fines’, which may comprise between 1 and 40% of a pulp. These fines have a great impact on the behaviour of pulp, on its processing, and on the characteristics of the resulting products. We compiled a review of research efforts to characterise the fines fraction by origin, morphology, and chemical composition, and to evaluate the fines’ effects especially in papermaking. The main feature of fines is the large specific surface area associated with their size. Their chemical constitution, particularly their charge, and the magnitude of their surface are the basis for their interactions with other pulp components such as extractives, fillers, and retention aids. The surface of fines affects drainage, as well as sheet density and strength. Several optical paper properties are influenced by the morphology of fines and by their chemical composition, which deviates from that of the long fibre fractions. The targeted utilisation of fines is a potential control variable in papermaking applications in order to obtain desirable paper properties.



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http://dx.doi.org/10.1016/j.pmatsci.2016.07.006
0079-6425/

## 1. Introduction

The most abundant source of cellulose is wood from trees. There, it is the main component of elongated cells commonly known as 'fibres', present as fibrils, which structure the cell walls and which are the basis of the mechanical strength of wood and wood-derived materials. A variety of mechanical and/or chemical processes exists to loosen fibres from the wood matrix, i.e. to create cellulosic pulp [1]. Any pulp consists of fibres of various lengths, as well as other wood tissue elements and fragments. Sizes range from a few millimeters (1–5 mm) for the largest dimension of fibres [2] down to colloidal wood resin of 0.1–1 μm [3,4]. The smallest components are called 'fines'; these are usually defined as those particles of a fibre suspension that can pass through holes of a certain size. Official standards suggest separating fines from the long fibre fraction with a metal plate with round holes of 76 μm diameter [5,6]. This corresponds to the most commonly used device, the nominal 200 mesh screen [6], which consists of 200 wires per inch (2.54 cm): therefore the term 'P200 fraction' is often used. If authors choose to separate their fines in a different way, say by a 100 mesh screen (150 μm holes) [7–10] or through 20 μm diameter holes [11], this has to be considered when evaluating their results.

This general physical description of fines applies to several different specimens. Depending on the kind of pulp, the fines fraction can include short fibres, fibre and fibre wall fragments, and cells of other types [8,12]. What distinguishes fines from dissolved and colloidal substances (DCs) that also pass through a 200 mesh wire is, on the one hand, that they are particles (i.e. retained on filter paper [5]), and on the other hand that they are visible in a light microscope [13], but the distinction remains unclear [14]. Some authors use the term 'cellulosic fines' to include colloidal cellulosic material (sometimes called micro-fines [15]), while excluding dissolved substances and colloidal wood resin. At the same time, inorganic pigments, fillers, latex, salt crystals, and precipitates that may also be present in papermaking pulp suspensions of a later process stage and pass through a 200 mesh screen are not considered to be fines [16]. Pulp is also produced from plants other than trees: for example from jute, hemp [17], sugarcane bagasse [18], or wheat straw [19]; these pulps also contain a large quantity of fines. This review, however, exclusively discusses cellulosic fines from wood.

A large share of pulp is used for papermaking; in 2013, the worldwide consumption of paper and board was 404 million tons, and the numbers have been growing [20]. Several studies on the properties and effects of fines have focussed on the production of rayon fibres, especially on whether and how to remove the fines from this process [21–23], but most fines research has been conducted with reference to papermaking. Early in-depth studies often concerned fines from groundwood pulp [24]. As a result, subsequent reviews focussed on fines of mechanical pulp [13,25], in which this fraction makes up 20–40% of the pulp by weight [13,26] and is crucial for the mechanical properties of the resulting paper. The fines of mechanical pulps are usually classified by their morphology; they are divided into fibrillar and non-fibrillar material [27]. This classification originated from the early observations of Brecht and Holl [24], and it is sufficient to characterise their papermaking properties [28]. Later studies showed that there is a correlation between shape and origin; the fibrillar material tends to be generated later in the pulping process [29,30].

Fines are much less abundant in chemical pulp, where the contents range from less than 1% to about 15% [22,31,32]. Early studies on the fines fraction of chemical pulps mostly recognised their high resin content, and consequently suggested removing the fines fraction, especially from sulphite pulp, to avoid problems in the subsequent processing [33,34]. While this may be an option for viscose production, fines are essential for papermaking – especially the secondary fines that are generated during the mechanical refining of pulp. Their interactions with other components within a pulp suspension are important for optimising both the dosage of additives and the properties of the final product [35]. To summarise, fines affect