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Research area: Product aims

Raw material // Fillers, pigments

Key words:

Extruder technology, microfibrillated cellulose (MFC), precipitated calcium carbonate (PCC), in-situ precipitation, fiber reinforced filler

Title:
Functionalization of nanostructures of the cellulosic fiber wall from saturated calcium solutions for the production of novel composites

Background/Problem area

Mineral fillers are indispensable in many industrial branches and are used in a variety of different materials. In plastic technology they act as a classic extender to lower the costs of the production process but also as "active fillers" to improve the property profile, including mechanical and optical properties. In the paper industry, fillers are also used to reduce raw material costs and to adjust the optical as well as surface properties.

However, fillers entail the problem that their application quantity is sharply limited. Inorganic fillers show no binding properties. They reduce the product strengths during higher use and lead to complications in the further processing of the products (e. g. increased dust propensity during the packaging and printing processes).

In order to expand the use of fillers and their positive effects on varying products and to prevent the negative effects of the material in parallel, mineralized cellulosic structures should be created for versatile applications in different branches of industry.

Objectives/Research results

To overcome this problem, the objective is to develop a process for the mineralization of microfibrillar cellulose by the precipitation and irreversible binding of $CaCO_3$ on the nanostructure of the cellulosic fibre wall. To ensure a high efficiency, the high consistency conditions in a twin-screw extruder are supposed to be used. The chemical pre-treatment of the cellulose and the application of a double exchange reaction are said to favour the ionic bond to the functional groups of the cellulose.

The idea of the production of fiber reinforced fillers is to precipitate calcium carbonate with a double exchange reaction from saturated solutions of calcium halogenides ($CaCl_2$ solution) and alkali metal carbonates (e. g. Na_2CO_3, K_2CO_3, NH_4CO_3, $NaHCO_3$). In this case the PCC modification can be controlled by careful adjustment of the precipitation conditions.

The concept for the mineralization of cellulosic structures involves the mechanically (fibrilling) and chemically modification and pre-treating (e. g. carboxymethylation) of the cellulose in the extruder under varying conditions prior to the carbonate precipitation so that surface modified, fibrillated cellulose (i.e. CMC) is available for subsequent process steps. This is charged in a second extruder pass with saturated $CaCl_2$ solution and the abovementioned precipitation reagents. Thus, the fibrillated cellulose is converted to MFC and simultaneously the $CaCO_3$ is precipitated on the nanostructure of the cellulosic fibre wall and irreversibly bound.

An additional advantage of the process is that both steps take place in completely aqueous medium.

Application/Economic benefits

$CaCO_3$ particles as well as cellulose fibres are used in manifold fields, for example in environmental, biological and process engineering as well as other techniques. The potential offered by the novel process for the mineralization of cellulose and the fiber reinforced filler (PCC-MFC-Nanocellulose) thus developed is correspondingly versatile.

In the field of papermaking, it is the goal and could be demonstrated in the first experiments that various paper properties such as strength and optical properties can be improved with the aid of mineralized cellulose. The filler content in the paper can also be increased so that a reduction of the raw material use as well as the production costs is possible.

The application of PCC-MFC-Cellulose is also conceivable in the field of plastics. In NFC (Natural Fibre Composites) and WPC (Wood Plastic Composites) as well as in PVC products, they can be used for strength and stiffness enhancement. Furthermore, fibres and $CaCO_3$ reduce the shrinkage of the plastic products and improve their optical properties. Accordingly, it is a cost-effective possibility to adapt and improve different plastic products both optically and mechanically.

A further idea is to use PCC-MFC-Nanocellulose in plaster for lightweight plaster walls. With the help of the composites, it should be possible to increase the porosity and the volume of the material and thus to achieve a weight reduction with constant component dimensions. In addition, the fibre network can increase the strength of the plaster walls.

Foamforming offers the possibility to develop new fibre based products as well as to reduce production costs and environmental impacts. It promises an ideal application for mineralized cellulose, as its surface properties support the voluminous formation of paper or fleece, reduces the material weight and increases air permeability. In addition, the composite increases the strength and optical properties of the products.

Period of time: 01.04.2017 – 30.06.2019

Remarks

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