Research Institute:

PTS Heidenau
Pirnaer Str. 37
01809 Heidenau

Internet: www.ptspaper.de

Head of the research institute:

Prof. Dr. Frank Miletzky

Project leader:

Dr. Alexander Feldner
Tel: 03529 / 551-624
Fax: 03529 / 551-889
E-Mail: alexander.feldner@ptspaper.de

Research area: Process aims

Paper and paperboard production // stock preparation

Key words:

Reactive extrusion, fibre modification, thermoplastic properties, fibre composites

TITLE:

Reactive extrusion of cellulose fibres for application in paper production

Background/Problem area

Cellulose fibres, in comparison to various polymer fibres, are not thermoplastic. At the microscopic level cellulose fibres are a heterogeneous system consisted of individual fibrils held by the adhesion forces such as enthalpy-driven ionic and H-bonds and dispersion forces. The same is true for paper that consists of individual cellulose fibres at the macroscopic level. On the contrary thermoplastics are a homogeneous system of interlaced polymer chains held together mostly by weak cohesive dispersion forces. To achieve the material softening upon heating, intermolecular bonds have to be destroyed like it is common for thermoplastics. It enables processing of polymers like injection moulding, film blowing or fibre spinning. However the adhesion forces in and between cellulose fibres are so strong that fibres decompose rather than start softening. The basic idea staying behind the present work is to substitute undesirable H-bonds on the surface of the fibres for the weaker dispersion forces through the reactive extrusion process.

The 'reactive extrusion' process is a mechanical equivalent to a 'one-pot' approach familiar in chemical industry. In the reactive extrusion, a compounding extruder is applied as a continuous reactor for carrying out chemical reactions rapidly at high consistency. Simultaneous impact of kneading, shearing, pressuring and heating results in highly homogenous products with the reduced amount of chemicals required. Along with the low reaction duration and the high stock consistency, it is the major manufacturing cost-saving factor. Reactive extrusion of cellulose fibres requires using a conventional co-rotating twin-screw extruder. Because of a wide utilisation of this type of extruders in the plastics industry the process up-scaling is facilitated.

It has recently been shown that cellulose fibres can be chemically modified in extruder. However no efforts have yet been invested in achieving thermoplastic or barrier properties of paper products by applying the reactive extrusion.

Objectives/Research results

The objective of the project is developing a platform technology for selective chemical functionalisation of cellulose fibres under solventless conditions in a twin screw extruder. It has been demonstrated that upon tuning the reactive extrusion conditions beside the thermoplastic cellulose fibres and thermoplastic polymer matrixes also anionic (carboxymethylated) fiber materials can be produced in a pilot-plant scale twin screw extruder. The anionic fiber materials may be thereafter converted into paper sheets. Because of the anionic character of the fibres, the strengthening properties are increased. Also the paper porosity as well as the air and water permeability decrease. By turn it opens new opportunities for novel products of packaging or lightweight construction sectors.

Application/Economic benefits

The project aims to support the SME in the pulp&paper industry in developing innovative packaging materials with a high amount of sustainable raw materials. In the papermaking industry new products can be developed for emerging markets also in the field of packaging. Here properties like plastic mouldability and high rigidity can be used to extend the application spectrum of paper products.

Period of time: 01.02.2015 – 30.06.2017

Remarks

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