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**Research area: Process aims**

Paper and paperboard production // Papermaking

**Key words:**

Cohesion, adhesion, material properties, surface modification

**TITLE:**

## Optimization of important material properties of natural fibers and their networks by fiber surface modification

### Background/Problem area

While paper pulp demonstrates excellent application properties in traditional graphic or packaging sector and can be thereafter generally recycled, its further expansion into other sectors is restricted by limitations of fiber properties. Among them are

- hygroscopicity of fibers and their swelling and shrinkage bound thereof,
- anisotropism of paper properties as a result both of fiber morphology and paper production process,
- dimension instability as a result of paper anisotropism,
- moisture dependent strength both of fibers and paper,
- dependency of fiber-fiber adhesive bonding capacity both on refining, filler, and recycling,
- poor binding capabilities between hydrophilic fiber surface and hydrophobic polymeric matrixes in composite materials,
- marginal thermal stability and potential pyrolytic decomposition upon heating.

To overcome weaknesses of cellulose fibers mentioned above, modification both of fiber amorphous domains and fiber surfaces can be applied.

### Objectives/Research results

The objective of the research project is to develop a technologically innovative and economically beneficial method of fiber modification aimed at returning natural properties of wood and wood fibers back, especially strength of fiber-fiber interactions, thermal stability and low water/moisture absorption and retention.

Improving adhesion between fibers and therefore paper strengthening was achieved upon fiber interface modification with polyelectrolyte multilayers (PEM) and polyelectrolyte complexes (PEC) based on cationic and anionic polyelectrolytes as well as anionic nanofibrillated (NFC) and microfibrillated (MFC) cellulose. As a result up to 150% enhancement of paper tensile strength was achieved.

High water and moisture sorption of cellulose fibers is a result of interactions between hydroxyl groups on a fiber surface and in amorphous domains and water molecules. To prevent it, chemical modification upon grafting-from polymerization of ε-caprolactone, esterification with acid anhydrides and in-situ formation of resins in fiber pores was achieved. By now 50% decrease in the water retention and 30% reduction of the moisture sorption was demonstrated.

To overcome marginal thermal stability of cellulose fibers, esterification with acid anhydrides as well as polymer crosslinking in amorphous domains was applied. Here, modified fibers and papers demonstrate higher thermal stability under model conditions (120 °C, 150 °C, 190 °C for 2-6h) in comparison with non-modified fibers and papers.

### Application/Economic benefits

The developed methods of fiber modification should open new ways to up to date inaccessible or hardly accessible applications for cellulose fibers. Among them are applying cellulose fibers in 3D-packaging and light weight construction, where high strength of individual fibers and fiber networks is strongly required. The increase in paper strength and dimension stability is crucial for decreasing the grammage and optimizing creep behavior of packaging paper, which leads to saving raw materials and minimizing transport costs and losses due to climate changes and long-term loading. Furthermore the improvement of the dimension stability should lead to the better processability of ink-jet, filter, and wall paper. Improving the thermal stability should lead to advanced applications of cellulose fibers in polymer compounding and 3D-formability by thermoforming and extrusion.

### Period of time: 01.10.2012 – 30.09.2014

### Remarks

The research project IK-VF 120021 is being funded by the Federal Ministry of Economic Affairs and Energy (BMWi).