

What keeps paper together inside

2,500 years of making paper – and we still have much to learn. Surface physics is entering a new research area and is enabling precise strategies where formerly only trial and error were possible. This is making paper better: more widely usable and of higher performance.

The topic

Packaging paper, as produced by the Mondi Group, has to satisfy high demands on consistency, stiffness and usability. The high quality demands have to be met alongside the demands on the use of materials and resources. To be precise: how many layers (i. e. material) are required for the desired quality and can the use of material be optimized (reduced) during the production procedure? The basic principle of paper production has been known for a long time: cellulose fibres are suspended in water and the fibres form a network on a sieve and bond to each other when they dry. However, the key question to control this basically simple process and to ensure a constant and high quality has still not been solved: what holds the paper fibres in the network together?

CD Laboratory for Surface Chemical and Physical Fundamentals of Paper Strength

Head

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Operation

01.03.2007 – 28.02.2014

Commercial partners

Kelheim Fibres GmbH, Lenzing AG, Mondi
Frantschach GmbH

Three questions to ...



DI Leo Arpa
Head of R&D Paper – Mondi Group

Why is basic research so important for innovation?

New knowledge in basic research is necessary for the development of new technologies and products. Products and processes that are built up on this basis have a better chance of long-term success on the market and of being advantageous to the client.

What are the biggest challenges in collaborating with universities?

Sometimes when two partners come together they first have to develop a common language and a mutual understanding for the collaboration to be successful. Working together for a longer term and mutual trust between them represent a good starting point.

What do you like most about the CD Laboratory funding scheme?

Apart from the lean management structure, the CD Laboratories are characterized above all by their medium-term horizon, which enables substantial progress in tackling even tricky problems. And we should also remember that the CD Laboratories benefit from the CDG's organization as an independent association with an experienced Scientific Board, which is consistent in applying bottom-up arguments and adhering to its demands for high quality in establishing the Laboratories as well as in evaluating them.

The research question: what causes the cohesion?

Paper has a very long history. After 2,500 years of production and about 1,000 years of more or less systematic research and development the general consensus was that the fibres are held together by both entanglement (friction) and hydrogen bonds. But the Mondi Group wanted to know more. Could forces other than friction and hydrogen bonds play a part? If so, can they be described and quantified and how can they be controlled?

Collaboration in the CD Laboratory

Its attempts at investigating these fundamental questions with the largest paper-related research institutes in Scandinavia seemed to be reaching a dead end, so the Mondi Group decided on a completely different approach. The company reasoned that a breakthrough would be much more likely if it looked at the problem in an interdisciplinary way, not only with the tools of chemistry but also from a physicist's perspective. An intense search ultimately led to the Graz University of Technology and to Prof. Robert Schennach, an outstanding surface physicist and chemist. He had previously had nothing to do with paper but was ready to tackle the company's basic questions. What mechanisms hold the fibres together and can they be quantified and controlled??

Results

The work in the CD Laboratory led to the identification and quantification of seven mechanisms with a role in the binding of fibres, such as the Van der Waals force, dipole linkage and mechanical interlocking. Another force was described for the first time and its mode of action revealed: a single-molecule film of water in combination with friction. The new knowledge is permitting the company to control paper quality more precisely. The research and the publications from the CD Laboratory have contributed to an advance in the field of paper. In the meantime, several research groups (mainly in Europe) are working in the area and establishing new expertise. The Mondi Group has been involved since the start of the development so enjoyed a head start; at the same time, the company is benefiting from the worldwide scientific advances initiated by Prof. Schennach. The company is ahead of its competitors in many performance indicators. The basic research benefited particularly from the programme's continuity: the scientists could work on the issue for seven years instead of having to spend time writing applications for funding.

Scientific challenge

The surface physicist uses a plethora of spectroscopic and microscopic procedures to study the properties of surfaces and their interactions with their surroundings. The challenge of working systematically with cellulose fibres requires a collaborative approach between chemistry and process engineering. Advanced knowledge on the structure of cellulose fibres is relevant everywhere where interactions between fibres play a part. Examples include not only paper but also textiles and new technologies for architecture, e.g. it might be possible to use paper walls instead of plasterboards in interior fittings.

Added value for the company

The results of the research have enabled many improvements in the company's wide-ranging portfolio of packaging paper. They lie at the heart of many products. Paper can be made more rigid and can be prepared with less resources. The research collaboration has made a significant contribution to the Mondi Group's success as a global producer of packaging and paper.