The Global Paper Industry Sustainability Through Paper Chemicals

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Bio-Data

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ABSTRACT

Since always, paper makers have optimized ways to produce paper and board efficiently. Major changes like producing paper under alkaline pH, utilization of recycled fibers or reduction in water consumption have contributed to improve the paper making cost performances. Today, the digital information coming directly on mobile phones or tablets is reducing the demand for writing and newsprint paper tremendously, creating a commoditization of the graphical segment. On the packaging segment, the demand for corrugated paper and packaging grade are contributing to the market growth especially in the Asia Pacific region.

As the paper machine automation and furnish composition have been already highly optimized, it is increasingly difficult to further reduce parameters like the energy or water consumption without the contribution of new paper chemicals solutions. Without the development of new and innovative chemicals, the ambitious goal of further improvement of sustainability in paper making is not possible.

For BASF, the sustainability of the paper making means striking the balance between the environment, social and economy needs. The paper chemicals contribute to speed-up the paper machines, reduce the paper basis weight or improve the runnability allowing paper maker savings. In our paper, we will present an overview of the global megatrends and some chemicals approach to tackle these objectives.

Introduction

In 2010, the paper and board demand reached 361 million tons and according to the Boston Consulting Group, this demand is supposed to reach 469 million tons with a clear decrease in graphical grades demand due to digitalization of the information and a strong increase in packaging board demand due to the emerging economies in Asia Pacific.

The Asia Pacific region shows the biggest growth fuelled by half of the world population concentrated especially in China and India. The emerging economies and disposable income rising population contribute to the demand increase in food and goods packaging.

As today paper machines consist of highly complex automation system, it becomes more difficult for this industry to further reduce their energy and water utilization through traditional ways. Therefore the paper chemicals must provide new solutions to traditional paper making to throw back their present limitations.

With increase of the planet population, the sustainability factor becomes a major driver in all industries. Paper making sustainability is targeting lower variable production costs through fibers furnish optimization, coat weight, filler content, basis weight reduction, or the substitution of the expensive fibers by lower cost fiber sources balancing the ecology, social and economic factors..

Global Megatrends

The world population is growing faster and faster and in nearly 200 years the planet population increased from about 1 billion in 1800 to 6 billion in 2000. This demographic change has been strongly accelerated by major improvements done in hygiene, health and nutrition all along the industrialization period. The gap between the industrialized countries and the developing economies populations requires huge resources demands in the future. (Figure 1)

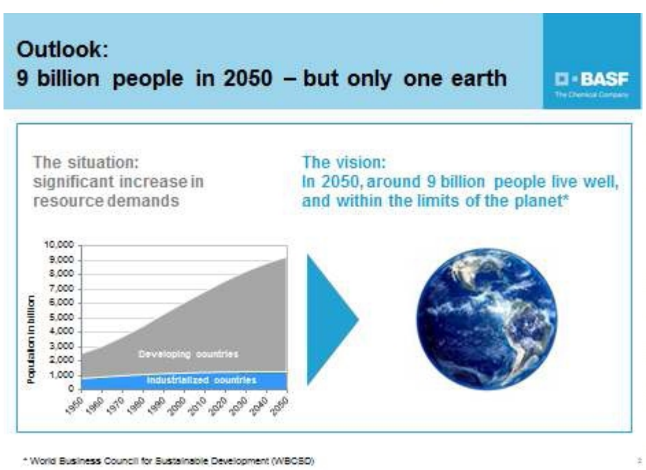


Figure 1: The world population situation

In 2050, the population is supposed to reach 9 billion people and we must live all together well within the resources limits of our planet.

If we consider water (the most precious resource) and energy as the most critical factors of sustainable development, their annual demand and regenerative capacity would be today unbalanced if all the countries were fully developed. (Figure 2)

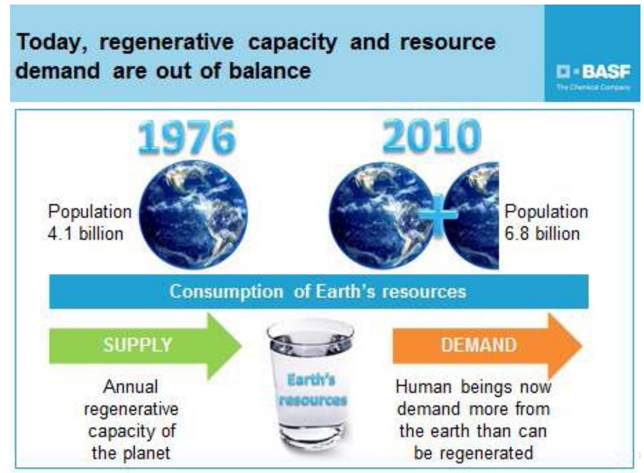


Figure 2: Unbalanced demand and capacity resources

About 99.7 % of all the water on earth is unavailable for human and animal. The most important aspect is the nonuniform distribution of this water on the planet. Some countries have no other choice than to use desalination (osmosis and flash distillation) process to balance their lack of water. This is particularly the case in the Middle East and in Saudi Arabia, 70% of the drinking water needs is covered by such units requiring huge energy amounts. (1)

As the population is growing constantly, our cities become bigger and more crowded, the constructions increase, the agriculture needs more land and water, the shipment transfer volumes between countries increase due to the market globalization. All those variables are creating constant demand increases in resources.

Figure 3: The world megatrends and the paper requirements

BACC, Shanghai, China
BASF SE, Basel, Switzerland

Such major changes are requesting new materials to be developed to ensure not only the demand but being sustainable in terms of recyclability and reduced carbon foot-print. Paper is one of the oldest and easily recyclable material invented by man among plastic, glass, metal and wood. Its utilization will remain essential in the day to day life for non-dairy beverage, protective packaging and food service markets.

The increased demand in new packaging is supported by an increasing population, claiming an attractive and efficient packaging to protect the good but requesting as well new properties like a better resealability, microwaveability or handling.

Today, our societies are more and more aware of the long term sustainability issue and this aspect is even more important for packaging which serves no function once the good is used or consumed in the case of food packaging.

For paper packaging, a sustainable material means a minimum of resources to make it (less fibers, water, energy), a lower transportation foot-print (lighter weight).

Between the years 1970-1980, the average paper bag had a weight of 247g, in 1990-2000, this paper bag weight was reduced by 13%. Other packaging like the plastics or the glass saw their packaging weight being reduced as well respectively by 45% (yoghurt) and 38 % (beer bottle). (2)

Definition of "sustainability"

A sustainable development is a balanced combination of economical, environmental and the social responsibility actions. Everyone has a role to play to maintain the planet resources more sustainable, thus to limit any waste of our limited and precious resources.

As described by Dr Allan R.Hoffman from the US department of Energy (1), water and energy are the critical elements of sustainable development, the water resources are no longer granted. The use of rivers fresh water in power plants are no longer possible and certain US states have to restrict such access to fresh water because the urban, agriculture and environmental interests were not balanced anymore.

For BASF, the importance of the sustainability is an important part of the company's target. The environmental, social and economic actions must reflect this will to create a sustainable world. Among those actions, the reduction in greenhouse gases, drinking water use and efficient energy consumption are focused on the environment aspects.

Safer working places and better health protection consist to the social aspect and finally increased sales and company profit contribute to leverage future new developments ensuring the company stability. (Figure 4)

BASF's corporate targets, covering all three dimensions of sustainability (BASF The Chemical Company)

Selected targets	Status 2012	Target 2020	
Greenhouse gases[1,2]	-31.7%	-40%	(baseline 2002)
Drinking water for production[2]	-23.2%	-50%	(baseline 2010)
Energy efficiency in production processes[2]	+19.3%	+35%	(baseline 2002)
Occupational safety[3]	-48.0%	-80%	(baseline 2002)
Health protection: Health Performance Index	0.89	>0.9	(annual goal)
Sales[4]	€72.1bn	€110bn	
EBITDA[4]	€10bn	€22bn	

[1] Per metric ton of sales product (excluding oil & gas)
[2] Figures are based on the scope of consolidation of BASF Group valid on December 31, 2012.
[3] Lost time injury rate per million working hours
[4] As of January 1, 2013, the accounting and reporting of the BASF Group is prepared in accordance with International Financial Reporting Standards (IFRS) 10 and 11 and with International Accounting Standard (IAS) 19 (revised). In March 2013, restated figures have been provided for 2012 to reflect the changes in accounting standards and the financial targets 2015/2020 adjusted accordingly.

Figure 4: BASF sustainability's targets

Sustainability in paper making

For the paper industry, the sustainability and especially the environmental aspect has always been a sensitive question as the society used to consider for many years this industry as a forest destructor. For this reason, all along the 20th century history, the paper industry has made major changes to improve their image. (use of recycled fibers, elimination of the chlorine bleaching, neutral pH paper making, water closure, trees plantation and forest growth control…) As the paper and packaging demand are growing every year, today's paper industry has continuously increased their output capacity and reduced their eco-footprint through improved automation system and a reduction in energy, fresh water, virgin fibers consumption. (Figure 5)

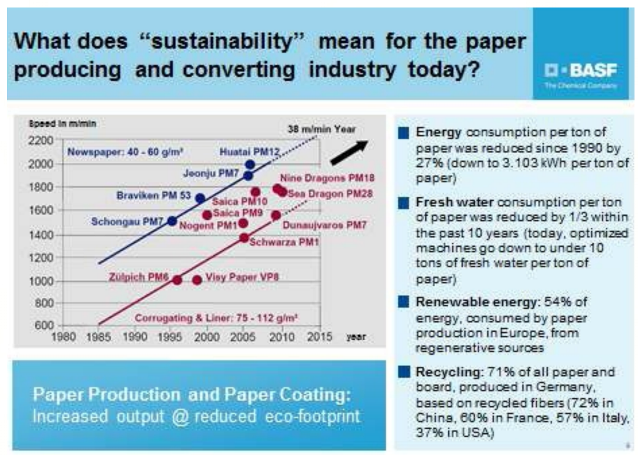


Figure 5: Paper making sustainability trends

In Europe, the energy consumption per ton of paper was reduced by 27 % since 1990, the water consumption went as well down to 1/3 within 10 years and today 54 % of the energy used by the European industry is coming from a regenerative source like harvest slash, bark, sawdust or sludge. The level of recycling in Europe just reached a high with almost 72% recycling (3) all over the different paper and board grades, this level is much higher than the plastic recycling varying between 15 and 30 % in 2011. (4)

This constant sensitization to the society of the forest preservation (most of the developed countries observed a growth of their forests, developing a sustainable forest life) has contributed a lot to improving the current image of the paper industry. The paper industry is one of the major players to decrease the CO_2 level in the atmosphere through the tree carbon storage. Finally, responsible production and consumption of paper products contribute to the long term sustainability of the paper industry.

BASF PVAm chemistry to enable wet-end sustainability

As mentioned in this paper introduction, the present world paper demand is expected to grow slightly with an expected world paper demand in 2020 of 469 million tons. The main segment to benefit from this growth will be the packaging segment, especially in the emerging regions (Asia Pacific and South America). Europe will maintain a positive growth in packaging and NAFTA will decline in packaging and fine paper.

Globally, as the graphical segment demand is reduced, solutions to reduce the total costs of operations in that segment become essential. In the packaging segment where the board production is expected to grow at 3% until 2020 (about 260 million tons projection in 2020), a demand for a TCO with a sustainability aspect is required.

Intelligent packaging solutions are needed to improve and simplify the recycling of our future day to day packaged goods. Examples of BASF sustainable solutions will be given later in the article.

The reduction of the Total Costs of Operations is a logical trend followed by the paper industry. The needs to increase the paper machine runnability and the paper formulation sustainability are the main focus of the paper makers. Some of the key driving actions in this context are the reduction of the coating application costs, the replacements of fibers by fillers, the substitution of higher costs fibers sources with lower cost fiber sources and the improvement of the production output of today's paper and board machines.

In the area of wet-end application, new solutions to reduce the Total Costs of Operations based on PVAm chemistry were presented at the Paperex 2011 edition by BASF. PVAm can improve the retention, dewatering, fixation and strength. It enables a break-through in cost reduction and sustainability. (Figure 6).

The cationic vinyl amine group (see Figure 7) develops a high anchoring power during the wet-end operations. This property enables the fixation of any hydrophobic substances on the fibers, preventing any deposit issues on the doctor blades and later on a better paper machine runnability. These properties are needed when the paper fiber quality is reduced, e.g. through the use of recycled or lower quality fibers, such as seasonal fibers like straw,

Figure 6: PVAm as wet-end enabler

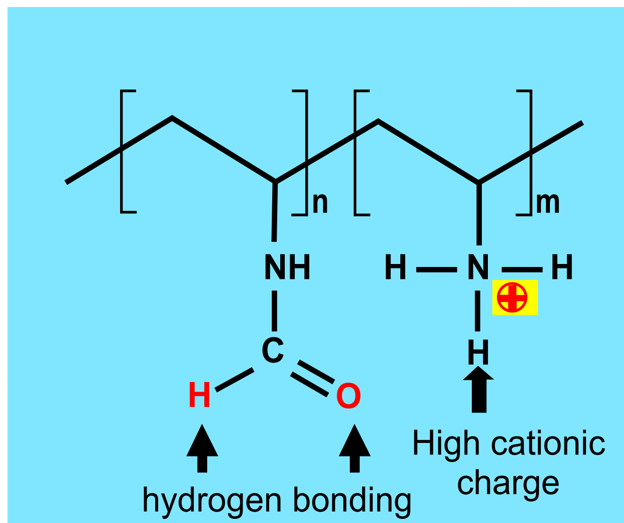


Figure 7 : PVAm functional groups

bagasse or even bleached mechanical fibers like alkaline peroxide tropical wood stone ground wood.

The presence of the vinyl-formamide groups increases the hydrogen bonding on fibers. This in turn increases the fibers-polymers interactions which increases the paper final strength or allows the use of lower fibers quality.

The following case (Figure 8) shows the benefit of using PVAm as a single component to increase the paper machine productivity and the filler content in the paper without producing issues like paper dusting and printability issues.

The addition of the **PVAm** has ensured a complete elimination of the RDF system, increased the machine speed and paper quality, resulting in a savings of 0.3 million US$/year.

Thanks to the high reactivity of the Vinyl Form Amide monomer, its copolymerization with other water soluble monomers is possible.

Mill overview
- Grade : newsprint
- Furnish : 100% DIP
- Filler content ~5-6% (from DIP)

Paper Machine
- Speed : 955 m/min
- Production: 100 kt/y
- Basis weight : 45 g/m^2
- PM : Semi Gap former

Wet End System
- PAm
- cPAM
- Cat. Starch

Objective
- Eliminate RDF, starch
- Increase filler in paper & printability
- Improve runability

Technical Approach
- Split addition with Xelorex™ (0.3% thick stock & 0.2% thin stock)
- 3% additional fresh filler

Results
- cPAM + PAm stopped
- Filler in paper up to 11%
- Speed increase to 970 m/min.
- Good runability & cleaner WW
- PM dusting reduction
- IGT Dry pick improved despite of higher ash in paper

Figure 8 : Total cost reduction using cationic PVAm approach

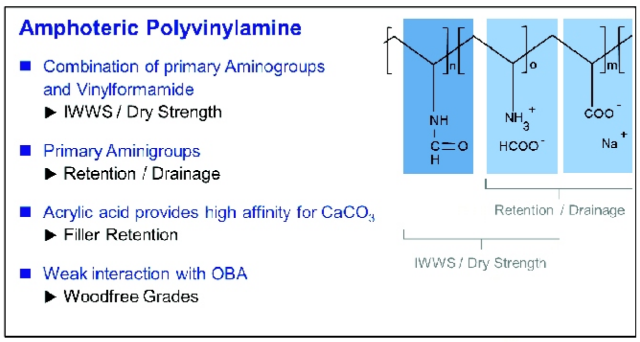


Figure 9: PVAm co-polymer for filler treatment

Through the copolymerization with the acrylic acid monomer, anionic groups can be added in the polymer back-bone providing particular properties of the final amphoteric polymer. (See figure 9) The presence of acrylate group provides a very good affinity to the calcium carbonate filler and thus particular interactions between the amphoteric PVAm with the fibers, the fillers, inter and intra polymer chains once adsorbed on the substract.

In figure 10, this paper mill example is using a commercial bagasse as a raw material and has the objective to produce themself this seasonal fibers with a higher yield than the present supplier. The bagasse has this particularity to contain a high level of parenchyma cells responsible for the linting and dusting quality issues.

Through the introduction of the PVAm into the filler line, before its injection by the fan pump, the paper maker could use 32% of its own bagasse production with a higher yield, without losing its copy paper quality. The paper machine first pass retention went up by 17 % with a reduction of 30 % in RDA chemicals. In total, the paper mill could save 0.5 million US$/year.

Mineral Oil Barrier sustainable solutions

Mill overview
- Grade : Copy Paper
- Furnish : 30% LF + 20% APMP + 50% commercial Bagasse
- Filler : 25 % GCC

Paper Machine
- Production : 100,000 t/y
- Basis weight : 70-90 g/m^2
- PM : Fourdrinier
- Speed : 650 m/min
- pH : 8

Current wet-end conditions
- Cat. Starch
- Micro-polymer RDF System

Mill Objective
- To use self-produced bagasse to replace more than 50% commercial bagasse without having runnability issues.

BASF Approach
- 0.3% addition of Xelorex™ in filler pipe, inlet at the mixing pump.

Results
- 1% sheet ash increase 21% to 22%
- 8% steam savings
- 32% self-bagasse pulp being used (Still 18% of commercial bagasse in furnish)
- 17% FPAR Increase
- 30% RDA saving

Figure 10: PVAm program on bagasse copy paper

The paper and paperboard segment is the largest sector in the global market for packaging, representing more than 40% of that market. The paperboard packaging still benefits from a green and sustainable image through its high recyclability compared to the use of other solutions like plastic or metal. Paper based packaging materials are behind one of the most innovative industries today developing new packaging shapes, structures or barriers functionalities.

The barrier's function is to protect the packaging content from external migrating elements through the packaging structure.

The most common barriers consist of the following polymers:
- Polyethylene
- Polypropylene
- Polyvinylchloride
- Polyamide
- Polyethylene-terephtalate
- Polyvinylidene chloride
- Polyvinylalcohol

The choice of the barrier type will depend on its efficiency to control the migration of hydrophobic and hydrophilic substances. Generally high hydrophobic barrier polymers are poor hydrophilic barrier polymers and vice-versa.

One of the food packaging industry focuses is the development of new sustainable barrier technologies for the Mineral Oil migration (oil residues present in recycled board) into food. (see Figure 11)

A coated barrier (Figure 11) is built between the recycled fibers and the dry food to prevent the mineral oil migration into the dry food. Different chemistries (PolyAmide, PolyButylenTerephtalate, Acrylic based dispersions) are presently under evaluation and some newly developed acrylic dispersions have shown very good performance profiles vs MOB, but as well other hydrophobic substances like oils,

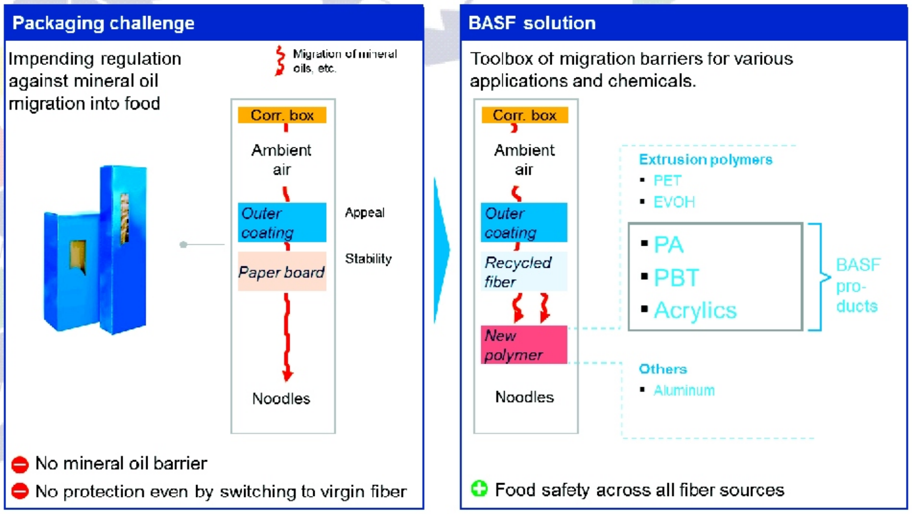


Figure 11: New BASF barriers solutions to MOB in packaging food.

native fats and flavourings.

Wood components as long term sustainable solutions

The understanding of the wood chemistry enables us to realize that most of the polymers (lignin, cellulose) and hemicelluloses (xylan, galactomannan,..) have a specific function. The access to such separate components is today the focus of many research institutes, universities and companies as it represents a potential source of chemicals used directly by the industry or being eventually chemically or mechanically post-modified before its utilization. (Figure 11)

For the paper and packaging industry, the use of the hemicellulose as dry strength agent has been already described in many literature but the access of a large amount of a pure hemicellulose is still today a challenge for the chemical industry. The lignin and the lignosulfonate, its most common chemical derivative from the sulfite cooking has already a large utilization as a construction chemical as a water reducer in concrete or in oil drilling; its usage in paper being marginal as a paper strength additive.

Today, as the cellulose remains one of the most important sources of available renewable and sustainable chemical on earth, many research programs in companies, universities and institutes are developing methods to get access to the mono-component of the wood fiber which is the cellulose polymer.

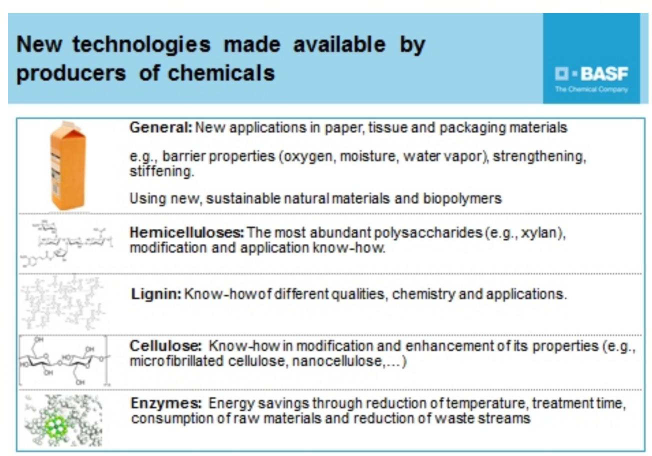
BASF paper chemicals division is developing a proprietary method to produce Micro-Fibrillated-Cellulose. The production of MFC is a technological challenge due to the difficulty to reach specific MFC morphology design and BASF is establishing a strong position in the development of MFC technology.

The wood fiber is made of complex blends of cellulose, hemicelluloses and lignin distributed specifically in their cross-section. The cellulose fibrils are dominant in the so-called secondary wall and particularly in the S2 wall.

During refining operations, this S2 wall surface is delaminated in fibrils hair (groups of macro-fibrils) producing the fibers fibrillation. The macro-fibrils are surrounded by residual low amount of lignin providing their cohesion. Each macro-fibril (about 10 to 30 nm) is composed of elementary micro-fibrils. An elementary micro-fibril is composed of about 100 cellulose chains (about 5 to 10 nm diameter) being compacted through hydrogen bonds and surrounded by hemi-celluloses. Thus, the regular fibrillation step involves specific engineering design generating blends of fibrial fines, micro-fines, micro-fibrilar cellulose. As MFC is an engineered material producing a complex blend of nanofibrils, fibrillated fines, fibers fragments and fibers, there can be various MFCs depending on the process used to produce them. The operation of standard pulp fibrillation produces a high heterogeneity of the fibers, fines elements, with an increase in BET specific surface. The MFC are more homogeneous material with a higher specific surface, the ultimate nano-size material being the nano-cellulose developing the highest BET specific surface.

The properties of the MFCs are still under deep investigations, the access to cellulose nano-fibrils represents a technological break-through in material innovation and BASF paper chemicals sees opportunities in the development of new paper strength solutions.

Conclusion



The engagement of the paper industry to ensure the sustainable future of the paper and board for the future generations is demonstrated by their efforts to maintain the best environmental (sustainable forest growth control, reduction in greenhouse gas emission), economical (improving energy efficiency, better paper recovering for recycling, fresh water consumption) and social practices (safer working place). The PVAm can contribute to optimize paper makers' raw material usage (fibers, fillers or waste), increase their energy efficiency (better dewatering, lower basis weight) without imparting the paper and board quality. New mineral oil barrier coating solutions enable the use of increased recycling fibers contributing to a sustainable packaging development. The introduction of renewable chemicals as paper additives like the Micro-Fibrillated Cellulose represents new sustainable solutions in paper making and BASF wants to be part of this partnership work with the paper makers.

Reference

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