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Application of Nano Technology in Paper Industry With Reference to Use of Pigments as Filler and Coating

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I. INTRODUCTION TO PAPER MAKING

To a lay man paper means a medium used for writing and printing. Over a period of time, since invention paper, there has been huge development in the industry and in today's world it has been difficult for human being to live without paper in all aspects of life viz. printing, writing, packaging, insulation, toilets etc. One of the main aspects of paper being printing. Printing industry depends mainly upon paper for its output.

Successful printings are to transfer ink onto printing stock in a controllable way to obtain word, solid and halftone image etc. In order to achieve stable printing effects, paper performance that can affect ink, printing technology and stock shall be strictly controlled.

Printability is a quality of paper as for whether it can copy an image stably. It is related with color density, levering of output solid, color tone range, hue and transitivity of ink. Satisfactory printability and runnability depends on performances of paper.

The quality of printed matters are affected by surface property of paper, interleaving paper and boards on aspects of optical appearance, ink absorbency, paper permeability, structure, thickness etc. Surface property of interleaving paper or boards are closely related to many elements, including nature property of used fiber, processing method, structure forms, spread coating and post-finishing procedures etc. One of the most important elements influencing quality of printed maters is surface structure of paper, usually referring to the smoothness or roughness of paper surface.

The smoothness of paper is generally decided by the forms of fiber. Polishing, spread coating, glazing and other post-press finishing processes can obtain a certain surface structure, meanwhile influencing the absorbency and permeability of paper, and the adhesiveness of ink in the end.

Absorbency, decided by density of paper, refers to the ratio of liquid (ink) entering paper through capillary action. As paper constitutes numerous tiny passages and pores, the capillary action depends on surface strength of paper, and tensile force and viscosity of ink.

Sloppy paper surface has many big pores which can absorb ink pigment and binders, while highly matted paper can only absorb ink binders. The amount of ink being absorbed into interleaving paper or board is crucial. If pigment stays on the surface of stock without being absorbed, ink can absorb lights effectively. More ink is absorbed into paper, more image loss would be incurred. Once upon being absorbed, printing primary color ink would lose luster, even change into different colors. What's more, black would lose brightness, even appear to be grey. The same kind of ink can show different colors after being applied onto spread coated material surface with small absorbency. Therefore, the capacity of paper to keep ink is important.

A. Fillers for Paper

Mineral (inorganic) fillers are applied in printing and writing papers. Organic fillers are only limited in use and if at all then for very specific reasons. The main mineral fillers are Talc, Clay, Kaolin, Ground Calcium Carbonate and Precipitated Calcium Carbonate. Another inorganic filler of importance is titanium dioxide, which is at low dosage provides extra high opacity and brightness to the sheet.

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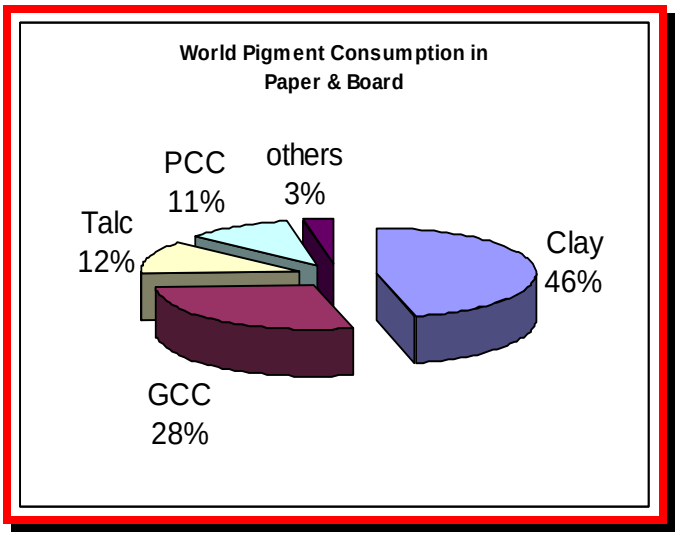

Figures 1: Word Pigment Consumption in Paper and Board

Mineral Content in Paper	
News Print	**0 - 15 %**
U/ctd mechanical	**0 - 40 %**
Ctd Mechanical	**20 - 45 %**
U/Ctd Woodfree	**12 - 30 %**
Ctd Woodfree	**35 - 55 %**

Table 1 : Mineral Content In Paper

B. Consumption Forecast of GCC & PCC in India in MT

	2005	2006	2007	2008	2009	2010	2011	2012	CAGR
GCC	**99**	**113**	**119**	**139**	**205**	**221**	**239**	**260**	17%
PCC	**5**	**5**	**5**	**23**	**111**	**203**	**233**	**240**	117%

Table 2: Consumption Forecast of GCC and PCC in India in MT

C. Selection of Fillers

Originally, fillers were applied, simply to increase the weight of the sheet. Today papermaker expects targeted multi functionality from the filler or the filler combination chosen. Quality and filler cost determines the choice of pigment for the individual application. If it comes to cost, not only the filler price itself should be considered, but the overall handling and application cost.

Different fillers have, for example, an impact on drainage, drying, sizing and OBA demand. The make down of a powder into slurry does not come for free either.

Paper industry uses several types of pigments for various applications of paper. The pigments being Talc, Clay, Kaolin, Ground Calcium Carbonate and Precipitated Calcium Carbonate and many others available on earth's crust. Depending on the end use of paper, various pigments are applied which depends on the value of the paper. Some of the pigments are used as fillers and some are for adding value to the sheet for high class printing.

D. Functions of Fillers

- *Sheet Formation*

Incorporation of pigments into the paper making process adds positively to sheet formation. Obviously there are so many other parameters having an impact on paper formation.

- Paper smoothness
- Brightness & Opacity

Different fillers and calendaring conditions provide different smoothness levels to the sheet. Also fillers very much influence the optical properties of paper. Depending on type of filler applied, sheet opacity and sheet brightness are usually significantly increased.

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- Printability
    1. Smoothness
    2. Ink absorption/affinity
    3. Print show through

The printability of paper is remarkably improved or influenced by the incorporation of pigments into the fiber web. The correct selection of fillers is particularly important for the most sensitive rotogravure printing process.

- Dimensional stability

Replacing relatively hydrophilic fibers by pigments makes more dimensionally stable paper.

- Cost

The incorporation of fillers in paper making process leads to dramatically lower furnish cost since fiber cost are usually much higher.

II. TRENDS IN PAPER PIGMENT INDUSTRY

Pigments available in the market are

1. Speciality Pigments : Plastic pigments, Titanium Dioxide and Hydred
2. Value added pigments : Calcined Clay
3. Volume Pigments : Talc, GCC & PCC

A. Why Pigments in Paper

1. Substitution of cellulose (Fiber) with filler to reduce costs
2. To solve technical problems
3. Improvement in paper properties within a grade

- Filler and coating pigments are one of the main product development tools
- Synthetic pigments are a convenient backbone for incorporating functionality into paper
- After micro size levels till nineties, pigment manufacturers have engineered at the nanoscale for years, but improvements in analytical techniques and production methods open up development possibilities.

a). Average Particle Size of Various Fillers

- Talc 5 – 15 µ
- Ground Calcium Carbonate 1 – 5 µ
- Precipitate Calcium Carbonate 2 – 10 µ
- Kaolin 1 – 50 µ
- Titanium Dioxide 1 – 5 µ

Paper making today includes, in principle, the same process steps as applied for centuries such as preparation of fiber material, sheet or web forming, pressing, drying, sizing and smoothing. However, in last two centuries much of the detail has changed. Each process step has undergone and still undergoes today intensive research and development work to meet economic and ecological requirement. All links in the chain between fiber and end user contribute to this progress. The chain does not only include the paper producing industry itself and its suppliers such as machine and chemical industry, but also the paper industry's customers and related industries e.g. printing houses, printing ink and printing machine suppliers and manufacturers of corrugated boards.

R & D focus has been on economic and environmental aspects such as

- Reduction in consumption of raw material, energy and water
- High machine runnability an long life time of machinery and its components
- Improvement of paper and board quality with respect to improvement of converting quality
- Quality of the product with respect to printability and ink consumption

Fillers and coatings replacing part of the expensive fiber material and improving quality of paper

After improving the economics of paper production with enhanced quality of paper and board, R & D has been engaged in development of further better grades of fillers to give an edge to printing industry for better printability and other requirements of printing industry.

A modern paper mill is an impressive sight, consuming vast quantities of trees, and possibly producing a thousand miles of paper every day. At first sight, nanotechnology appears to be the very opposite of this ancient and large-scale technology – something very modern and very small. Yet nanotechnology is creating revolutions in many fields working at much larger scales. A good example is electronics, where the relentless drive to reduce the size of components has brought integrated circuits down to nano meter dimensions. Another growth area is nano particles, used in an astonishing range of products, although many of the innovations simply continue trends that began with larger particles. Papermaking has in effect been practicing nanotechnology for centuries. The basic structural elements of paper, i.e. cellulose fibers, are true nanostructures, as are many of the other added components such as fillers (nano particles) and sizing.

Nanotechnology offers papermaking great potential to enhance existing products and to enable new roles. Some critics raise objections to the idea that nanotechnology and

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papermaking are closely linked, on the grounds that papermaking is essentially a statistical process and therefore opposed to the 'classical' concept of nanotechnology, according to which the position of every atom is specified and controlled. Be that as it may, there is relentless pressure in the industry to increase the rate of production, and businesses will adopt any technological developments that increase efficiency and quality while decreasing costs.

Paper is a thin sheet material made from vegetable fibres felted together. Its earliest and most important use is as a substrate for writing produced by hand or by some mechanical process such as typing or printing. It is therefore distinct from other substrates such as papyrus, rice paper, parchment and vellum. According to D Hunter, paper is defined as a thin sheet made from fibres that have been macerated until each individual filament is a separate unit; the fibres are then intermixed with water and, using a sieve-like screen, they are lifted from the water in the form of a thin stratum; the water drains through the small openings of the screen, leaving a sheet of matted fibre on its surface. Most paper is made from cellulose, the main structural material in the plant kingdom. In principle, any form of cellulose may be used as raw material for papermaking, but the overwhelming majority comes from trees. Unusual plants may be used for special papers.

III. WHY NANO PIGMENTS

- Fillers and coating pigments are one of the main product development tools.
- Synthetic pigments are a convenient backbone for incorporating functionality into paper.
- Pigments have been engineered at the nanoscale for years, but improvements in analytical techniques and production methods open up development possibilities.

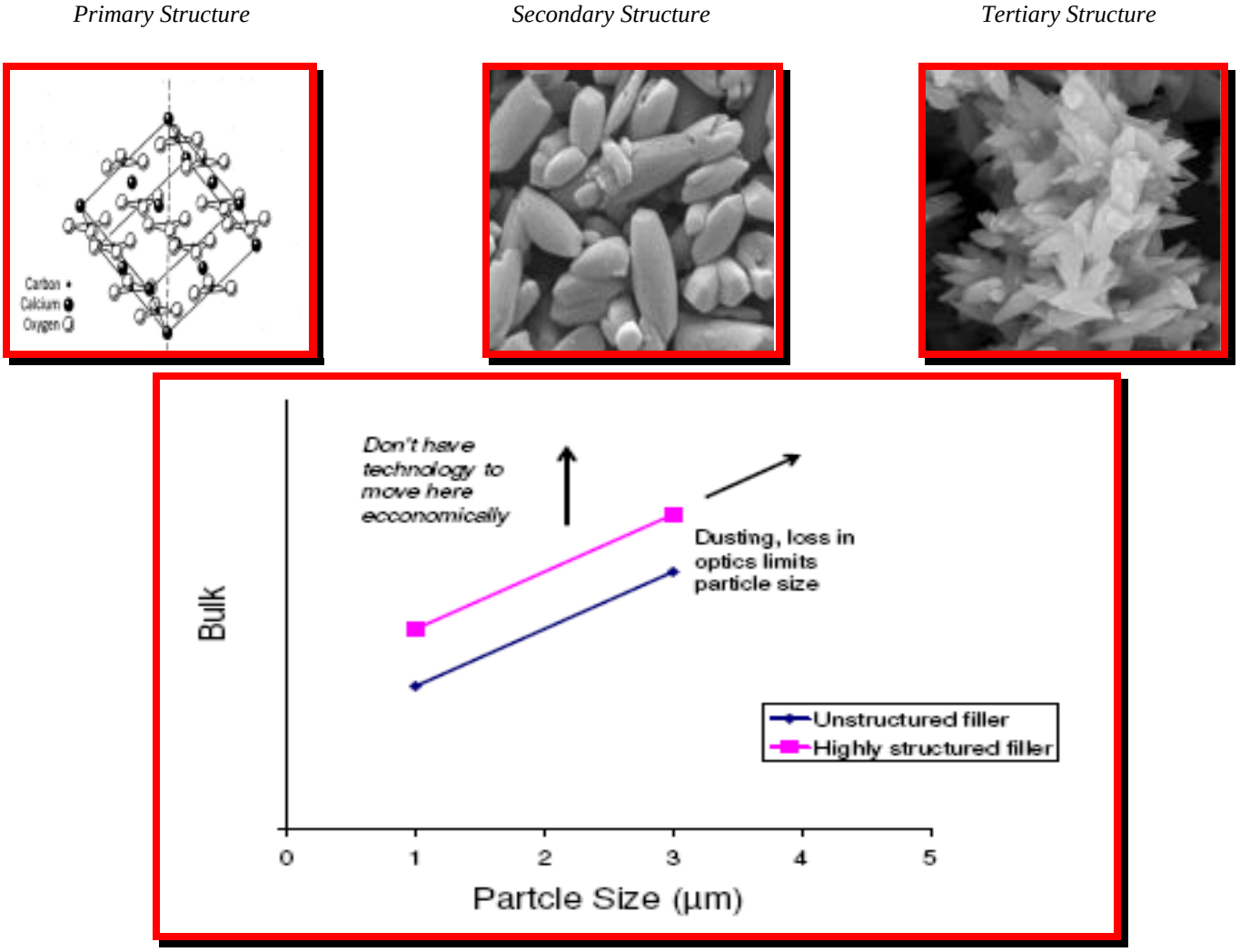

Figure 2: Nano Pigments

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A. Designing A Composite Speciality Pigment

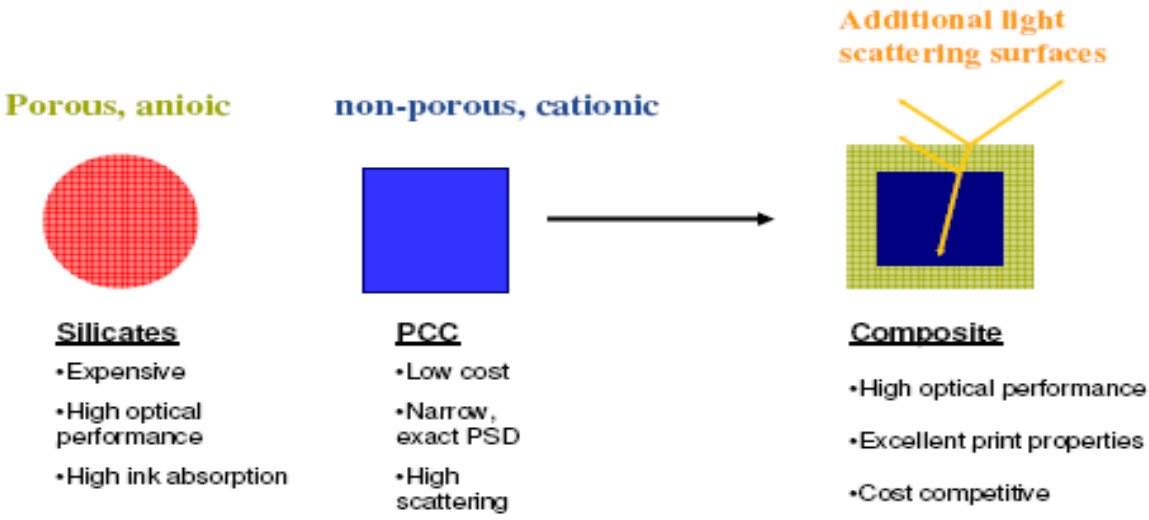

Figure 3: A Composite Pigment

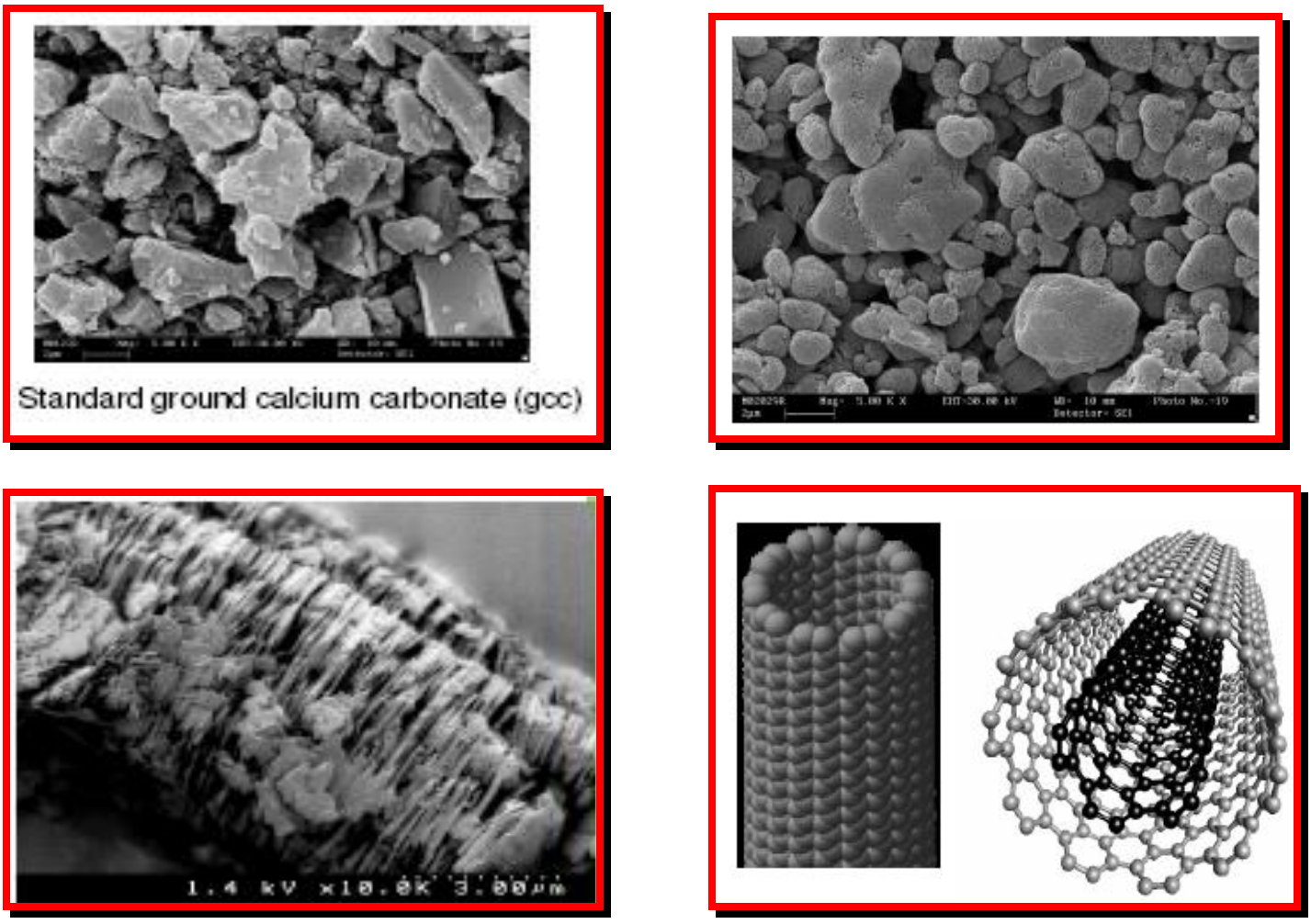

Figure 4: One Dimensional Pigment in Paper

Carbon annotates are receiving wide attention for the unique properties these exhibit. One dimensional structure has also been started for use in paper.

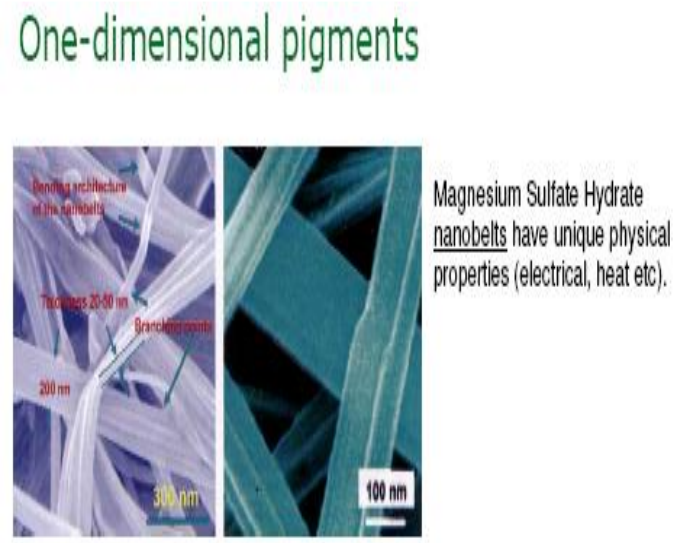

Figure 5: One Dimensional Pigments

Nano plastic pigments with particle sizes as small as 30 nm have already been in use. They are used alone or in combination with a carrier inorganic pigment such as kaoline and calcium carbonate for porous surfaces. The low particle size means that only small amounts of material are required to cover the entire surface.

During the paper production process the Nano particles do not film-form. It is this characteristic that is responsible for a number of improvements in the final properties of the paper. For example, ink applied to paper treated with Nano particles dry more quickly as it is drawn into the capillary-like spaces between adjacent particles. Hence image sharpness and depth of color are improved.

The Zetasizer Nano's role in the development and manufacture of NanoTope has been two-fold: first in supporting the creation of a stable monodisperse suspension of nanoparticles of defined size; and second in quality control, to ensure the production of consistent materials. This has resulted in good understanding and control of those parameters affecting product performance, shifting quality assurance away from simple reliance on end product testing.

IV. CONCLUSION

Acceptance of new technology by the paper industry often takes time, and is so gradual that it becomes difficult to assign precise introductory times to novel products. The first public presentation of the Allied Colloids new Hydrocol bentonite process is recalled to be at a Canadian Pulp and Paper Association meeting in the late 70's. The Eka Compozil colloidal silica process is probably of about the same era.

Initially, the nanoflocculation process was poorly understood, the subject of much trial and error. Nanoflocculation is far superior to macro flocculation, even though usually executed with a chemistry efficiency of only about 10%. Homogeneity at 2 critical junctures is typically not achieved, and the repulsive surface force remains, to forever degrade strength properties.

The principal scientific objective is to increase intermolecular contact, and maximize all the available attractive forces. They are extremely powerful, and they are free! Included are van der Waals Force, hydrogen bonding, preferential wetting, electrostatic attraction and interparticulate coupling. Detailed discussion is beyond the scope of this review.

The first step is to use a mono-functional cationic chemical, such as cationic starch. It should be cost-effective in charge neutralization and high enough in molecular weight to remain on the cellulose surface. Sufficient quantity is added to make the stock positive, with a zeta potential in the range 5-10mV.

The use of highly engineered materials can greatly enhance new product possibilities and allow technical differentiation of paper companies. Need strong academic research on particle synthesis and production techniques especially calcium carbonate technology.

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