

Alkaline conversions in North America gain momentum as mills take advantage of high-quality, lower-cost papermaking

Marella Synovec

In North America, as it has been in Europe, calcium carbonate will be the key to higher quality, greater productivity, and improved economics in both paper coating and filling.

Introduction

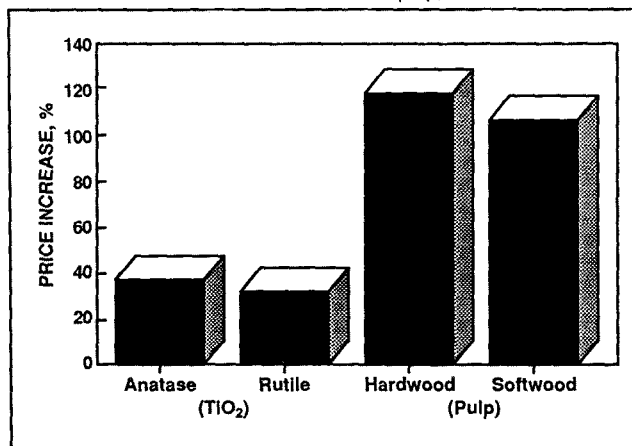
Alkaline papermaking technology has been available for over 25 years, but only in the mid-1980s did it begin to gain ground in North America. In the 1970s, the paper industry devoted significant resources and energy to environmental issues such as revitalizing lakes and rivers, yet might not have realized that alkaline papermaking could be part of the solution. Furthermore, among North American paper producers, there was little enthusiasm to change from acid papermaking: incentives to save on fiber and energy costs were weak, domestic production of ultrafine ground limestone (UFGL) suitable for paper fillers did not exist, and the two largest producers of precipitated calcium carbonate (PCC) had closed down, reducing domestic production by more than 50%.

In the 1980s, however, several factors came together to start the push toward alkaline papermaking as a means of both satisfying consumer demands and lowering costs. Ultrafine ground calcium carbonate became available and PCC production capacity increased. The availability of titanium dioxide (TiO_2)—the paper industry's workhorse coating and filler pigment—tightened, and its price began to climb.

Many producers were also caught off-guard by a tighter supply and rising prices of market pulp. Advertisers and other paper consumers were demanding higher brightness and opacity. There was increasing concern about the use of chemicals such as optical brighteners as well as overall quality issues. Another influence was the increase in imports of European papers; in particular, most of the wood-free imports were alkaline papers.

As the change from acid-based systems gains momentum, papermakers have been striving to work through the chemistry while meeting existing specifications. Alkaline chemistry can produce higher quality paper that may

1. Price increases in titanium dioxide and pulp, 1985-1989



exceed existing specifications, and some mills have been challenged to meet product specifications because of this. For example, about 18 mills in the United States are qualified to supply Xerox paper. These producers are required to meet the same specification with the understanding that each mill's product can perform interchangeably. Because the specification developed from acid-produced papers, some of the mills had to compromise some of the quality and economic advantages of the alkaline conversion in order to meet the specification.

As paper mills begin to optimize alkaline systems, substantial savings will come from fiber replacement via higher filler loadings. Calcium carbonate, particularly ground CaCO_3 , will be the key to higher quality, greater productivity, and improved economics in both paper coating and filling (1).

Momentum growing

European papermakers have been utilizing alkaline papermaking and realizing significant cost savings by

Synovec is a freelance editor and writer, 2644 Woodacres Rd., Atlanta, Ga. 30345.

using higher filler loadings for fiber substitutions since the 1970s. North American papermakers initially envisioned the conversion to alkaline papermaking as a means of limiting the use of titanium dioxide pigment, but it became apparent that the alkaline process would save on fiber costs. While pulp prices rose more than 100% from 1985 to 1989, titanium dioxide price increases were about one-third of that during the same period. These price increases are illustrated in Fig. 1. The potential for cost savings in filler for fiber substitution is particularly significant in light of the fact that fiber accounts for 85% of paper and TiO_2 for less than 2% (2).

As evidence of the growing momentum toward alkaline papermaking, in 1989 about 50 mills in the United States used alkaline processes; these mills produced 30–40% of all domestic coated and uncoated free sheet paper. By the end of 1990, alkaline-produced wood-free paper production in North America approached 9,000,000 tons, or more than 50% of total capacity (2). The momentum of free sheet alkaline conversion has recently caused significant interest in groundwood-containing mills. Thus far two mills utilizing technology from Omya, Inc., Proctor, Vt., have converted to alkaline/neutral papermaking. The change has provided improved paper properties and machine runnability.

Printing and writing papers

Alkaline sizing is commonly used in the manufacture of coated and uncoated free sheet printing and writing papers. In North America, alkaline sizing in coated free sheet had increased from 58% in 1988 to 86% (4,000,000 tons) in 1990. Alkaline sizing in uncoated free sheet during the same time period increased from 22% to 66% (about 9000 tons).

Filler loading levels in Europe average over 20%. The range in the United States is 7–18% with a few mills filling up to 26%. As the paper industry in North America becomes more comfortable with the chemistry change, filler levels will increase, primarily with calcium carbonate, which has a cost/performance advantage over lower-brightness fillers such as clay. As a result, higher brightness and opacity and improved printability can be achieved, all at lower cost. The increasing availability of calcium carbonate fillers and the increasing utilization of alkaline processes are expected to boost loading levels in all grades of North American papers to an average of 20% by the middle of the decade and to 30% by the year 2000 (1, 2).

Potential savings due to increased filler levels for a paper mill producing 100,000 tons/year is shown in Fig. 2.

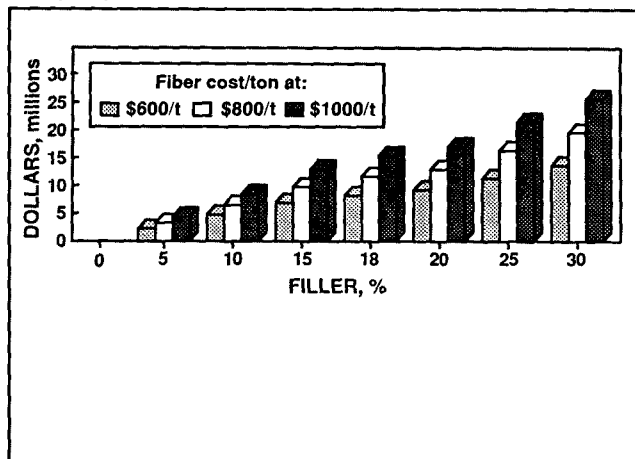
Industrial minerals in papermaking

Mineral consumption

Fillers such as TiO_2 are added to pulp to increase opacity and sheet brightness. The choice of the best filler for a mill depends on such factors as the filler cost, its quality and availability, its effect on mill runnability, paper quality, and the mill's grade structure.

The North American paper industry consumes a large quantity of industrial minerals, particularly clay, calcium carbonate, and titanium dioxide. (See Table I.) During

2. Savings in furnish costs per year with increased filler at 100,000 tons/year production



1. A comparison of industrial minerals consumption by the North American paper industry for the years 1984 and 1989 (3)

	North American consumption 1984/1989 (1000 short tons)		
	Filler	Coating	Total
Clay	1085/1400	2064/2800	3149/4200
CaCO_3	353/732	100/347	453/1079
TiO_2	132/154	101/117	233/271
Total	1570/2286	2265/3264	3835/5550

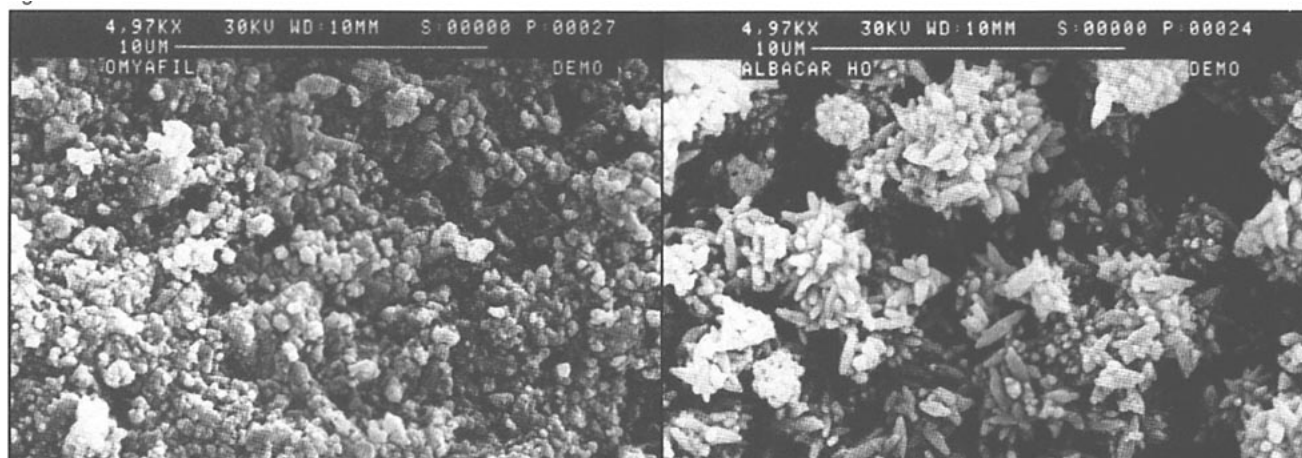
1984–1989, paper industry consumption of industrial minerals grew at the rate of 8.7% per year, while consumption of calcium carbonate grew 27.6% per year. During the same period, calcium carbonate consumption grew from 11.8% to 19.6% of the major minerals used by the North American paper industry.

In Europe, calcium carbonate accounted for 30.3% of the paper industry's mineral consumption in 1984 and 37.4% in 1988. Calcium carbonate use was a natural evolution in Europe because paper producers enjoyed a high-quality mineral supply that was locally available at low cost.

More complex issue

In North America, however, calcium carbonate consumption in alkaline conversion has been a more complex issue. High-quality kaolin pigments continue to be readily available at low cost. It is generally acknowledged that no one has developed a replacement for the effective, but costlier, titanium dioxide pigment, although TiO_2 extenders (i.e., ultrafine ground limestone, calcined clay, zeolites, filler clay, PCC) have been successful. However, TiO_2 has been overused in order to beat production variability and meet or exceed specification, or it has been used strictly for brightness. Scalenohedral precipitated calcium carbonate (S-PCC, or PCC) is useful in alkaline papermaking, but some S-PCC users are using as much or more TiO_2 as before converting. Some suppliers also report that TiO_2 consumption by the paper industry is increasing (1).

3. Particle structure of Omya, Inc.'s ultrafine ground limestone (Omyafil), left, and Pfizer, Inc.'s precipitated calcium carbonate (Albacar HO), right.



II. Filler properties and morphology of commercial UFGL and P-CCC (5)

	UFGL	S-PCC
Mean particle size (microns)	0.7	1.3
% < 2 microns	90	90
% < 1 micron	62	28
% < 0.5 micron	35	7
Brightness (Elrepho, %)	96	97

Printability, economics drive mineral use

Printability and economics are the key reasons behind the use of minerals in paper. Advertising is the driving force for print quality; and, in newsprint, printability is becoming increasingly important as consumer demand for color increases. Minerals are critical to color printing in newsprint.

Economically, minerals are less expensive than fiber and most paper grades benefit from the substitution of minerals for fiber. Minerals also enhance other paper properties such as brightness, opacity, and smoothness. Machinability/runnability and the chemistry of the system are operational factors that influence mineral selection.

While most pigments can be run under acid or alkaline conditions, the use of calcium carbonate is restricted in acid environments because it is easily dissolved in acid. However, ultrafine ground calcium carbonate has the advantage of high brightness and better drainage and rheology.

Alkaline papermaking also produces paper with a longer life span. Paper produced from acid processes has a life span of about 50 years, which shows in the yellowing and crumbling pages of old books and documents. Alkaline-produced papers can exist for more than a century without significant change.

Calcium carbonate's evolution in North America

Calcium carbonate's merits in paper coating have been recognized for several decades, but its use in the earliest phase of alkaline conversion was limited to not more than 25% of total coating pigment. As more wet-end conversions took place, paper coaters increased the level of ultrafine ground limestone in coatings to enhance coating rheology, brightness, coating lay, and printability.

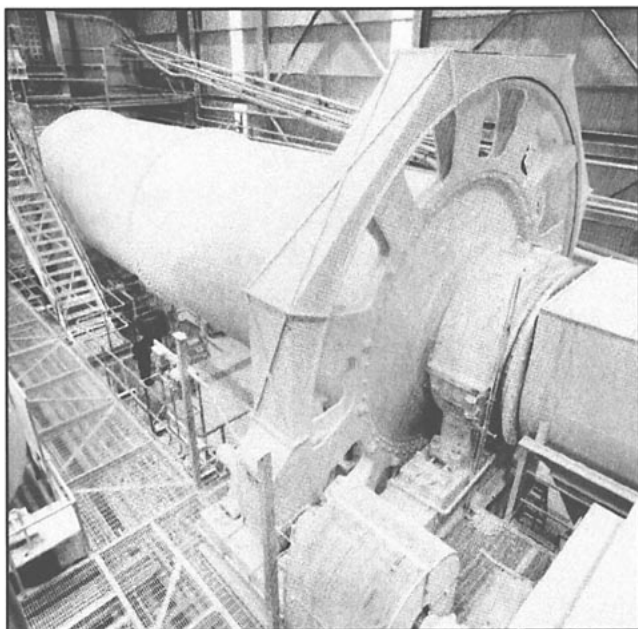
Uncoated wood-free conversions yielded higher paper strength, which led to higher filler levels and cost savings. Still, the use of calcium carbonate was hampered because paper producers sought to match existing acid grades. Momentum has since shifted from an environment of "production push" in which paper production and marketing personnel resisted change to one of "customer pull" in which paper producers are subject to market demands. The emphasis has moved away from matching existing grades to recognizing that it is possible to improve paper quality with alkaline processes. Alkaline paper has been accepted as higher quality and is often specified by certain market segments. As a result of this shift in emphasis, nearly 50% of all U.S. wood-free producers and all major European wood-free producers use alkaline processes (3).

The use of calcium carbonate in filling and coating is a major factor in the development of high-quality alkaline papers. Now in North America as well as in Europe, calcium carbonate is the primary filler for alkaline papermaking because of its high brightness, blue white shade, opacifying power, and availability at low cost.

PCC and UFGL are CaCO_3 filler choices

Two forms of carbonate filler are available to papermakers: ground limestone, a natural product made using highly sophisticated wet grinding technology, and precipitated calcium carbonate, a manufactured carbonate made by passing flue gas through a milk-of-lime solution. Both products take the mineral form of calcite but are available with different morphologies. The wet ground limestone has a rounded particle structure, while most PCC is available in a scalenohedral morphology, commonly

4. The Ball Mill at Omya's ultrafine ground calcium carbonate plant in Florence, Vt.



referred to as a rosette (4). Both forms are represented in Fig. 3 and their filler properties and morphology are presented in Table II.

Major North American producers

The North American carbonate filler industry comprises about 25 companies, with 7 serving the paper industry; these companies include both ground carbonate and PCC producers. The dominant producer of PCC is Pfizer Inc., which has led a trend toward producing PCC on the same site as the paper mill. Such on-site PCC plants take advantage of available resources at the mill site (i.e., carbon dioxide, process water) for processing PCC and eliminate some transportation costs of filler to the mill site. At the end of 1990, Pfizer Inc. had 18 on-site mill facilities in operation. Other major PCC producers in North America include GK Carbonate and Mississippi Lime. During 1989, the total PCC production capacity for the United States was 600,000 tons (2).

Among the ground carbonate producers, Omya, Inc.'s plant in Florence, Vt., is the fourth largest in the world. (See Figs. 4 and 5.) Most of the plant's annual production volume—400,000 metric tons, with plans to expand to 750,000 by mid-1992—is committed to the paper industry, according to Tom Daly, Vice President of Sales and Marketing-Omya North America. Omya has two other plants in Vermont, one of the richest high-grade limestone regions in the North America. Another plant is in operation in Southern California, and Steep Rock in Perth, Ont., Canada, was brought onstream recently, Daly said.

Omya achieved its status as a leader in ground calcium carbonate production by providing "an extremely high quality product backed by good technical service in a market that was ready for it," Daly said. "Omya created the alkaline papermaking market [in North America]. Prior to the opening of this plant, there wasn't a paper

5. An innovative statistical process control system provides necessary graphic data of critical operations at Omya's ultrafine ground calcium carbonate plant in Florence, Vt.



mill around using ultrafine ground carbonate coating. Now, every piece of No. 1 and No. 2 papers have calcium carbonate in them."

Joint venture

In early 1992, Alabama Carbonates LP, a joint venture between Omya's parent Pleuss-Stauffer of Oftringen, Switzerland, and Georgia Marble, is scheduled to begin operation at Sylacauga, Ala. Georgia Marble will supply the raw materials and Pleuss-Stauffer, through Omya Inc., will supply state-of-the-art processing technology. According to Omya literature, such a venture can benefit papermakers by taking advantage of highest quality calcium carbonate pigments, one of the world's most modern CaCO_3 processing facilities, proprietary process technology, access to the industry's finest technical service center, and high-quality ore deposits.

For the paper industry, Omya offers three products in slurry, dry bulk, and 50-lb bags: Hydrocarb 90, the premiere calcium carbonate coating in America; Hydrocarb 60, which has a larger particle size designed to be used as either a coating pigment or a filler; and Omyafil, designed as a filler pigment only.

III. Projected consumption of industrial minerals by the North American paper industry for 1994 (1000 short tons). Projections are based on the assumption of 4.9% related paper growth, 2.7% TiO_2 growth, 5% increased filler level, and CaCO_3 adjusted to 25% of all coating pigment (3).

	Filling	Coating	Total
Clay	1200	3225	4425
CaCO_3	1916	1075	2991
TiO_2	171	129	300
Total	3287	4429	7716

"Omyafil has been extremely effective as a filler pigment," Daly said. Proprietary equipment and techniques developed by Omya engineering personnel have allowed Omya to set new industry standards for its products, which are regarded as brighter, capable of providing higher gloss, and exhibiting superior rheological properties.

PCC and UFGL compared

The predominant filler grade ultrafine ground limestone (Omya's Omyafil) and the predominant PCC (Pfizer's Albacar HO) currently available have been compared at equal filler loading on a commercial paper machine as well as a pilot paper machine. In both cases, S-PCC produced better opacifying power at equal filler levels compared to UFGL, which is directly related to the light-scattering superiority of S-PCC. However, S-PCC was shown to be inferior in sheet strength characteristics because it tends to de-bond the sheet more than UFGL.

Strutz *et al.* (4) evaluated UFGL and S-PCC at equal opacity on the same commercial paper machine used in the previous study. The following is a summary of results:

- At equal filler levels, the UFGL showed a 6% improvement in reel speed and a 19% improvement in reel speed at equal opacity. The improvement was due to the faster-draining UFGL at equal filler levels and to the higher filler content in the sheet at equal opacity.
- Higher brightness (a difference of about one point) can be expected with UFGL when compared at equal opacity while S-PCC shows slightly higher brightness at equal filler content.
- At equal filler level and at equal opacity, the S-PCC sheet showed more bulk, about 0.2 mils, which would not be critical to most paper grades.
- The slightly higher bulk in the S-PCC sheet was not reflected in stiffness, possibly due to weaker internal bonding in the S-PCC sheet.
- S-PCC showed weaker internal bonding in both the comparison at equal filler level and at equal opacity.
- At equal opacity, there is no significant difference between the two fillers in tensile breaking length or bursting strength.
- UFGL shows better sizing at equal filler level and at equal opacity.

Filler optimization

As alkaline conversion continues in North America, the demand for calcium carbonate fillers is likely to be strong. Table III provides projected minerals consumption for 1994. While producers of carbonate fillers acknowledge a place for both ground and PCC grades, the belief has been expressed that the performance of PCC will deteriorate as paper filler levels increase to 20-30%. At such high loading levels, the use of PCC may create problems of poor drainage and increased water retention, resulting in machinery slowdowns and rising drying costs (2).

While both forms of carbonate are used by some alkaline mills as their sole source of filler, blends of both can be used to optimize the opacity and production goals for a

particular grade. For instance, a higher proportion of precipitated calcium carbonate is used for the higher opacity grades while more UFGL is used for the heavier weights or grades where opacity is easier to attain. Ultrafine ground limestone can be used to achieve the same opacity, burst, and tensile strength as PCC by using approximately 50% higher filler levels (4). □

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