CHAPTER 1

Pigment Coated Paper and Paperboard

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WHY APPLY COATING TO PAPER AND PAPERBOARD?

THE principal reasons for applying a pigment coating to paper and paperboard are to improve printability, appearance, optical properties, and, in some cases, barrier performance. In its simplest form the coating consists of a pigment and an adhesive (binder) to bind the pigment particles both to one another and to the base paper. Pigments are the main constituents by weight of most coatings, generally in the range of 80%–95%. The binders and additives normally comprise ≤15% by weight of the coating formulation for printing and writing paper or ≤20% for coated paperboard. However, the pigment level will be much lower and binder level will be much higher for barrier coating. Pigment coating provides a surface that is more uniform in appearance and more receptive to printing ink than the uncoated paper fibers. This, in turn, facilitates the printing process and enhances the print reproduction and quality. The improvement in print quality is readily apparent, especially in image areas or when multiple colors are involved. In addition, pigments with platy shapes (e.g., kaolin clay and talc) also are used in barrier coating for protection against oil and grease, water, water vapor, and oxygen, and mineral oil; calcined clay and synthetic hollow pigments are used for thermal barrier. Mineral pigments in coating do not interfere with repulping, recycling, or composting. In this book, pigments refer to mineral-based, white or near white, relatively insoluble amorphous or crystalline inorganic materials, with the exception of synthetic plastic pigment.

HISTORY OF COATED PAPER

The origin of coated paper is obscure. Historical references indicate that efforts to coat paper with pigments were made as long as several hundred years ago [1]. The Chinese were probably the first to coat paper, using gypsum as the pigment and animal glue or starch as the binder, in about 700 A.D. [2]. The volume of coated paper production was small, if not insignificant, as late as 1850. The use of kaolin in paper coating was first disclosed in 1870 when a patent was issued to H. D. Pochin and Co. in England [3]. In the latter half of the nineteenth century, the situation changed markedly when substantial technical effort resulted in the development of mechanical methods for coating paper on a commercial scale. These early coaters used a brush to apply followed by brushes to smooth the coating before being festooned to dry. The process was slow and relatively inefficient, but the high aesthetic appeal of the finished paper commanded the premium in price necessary to compensate for the manufacturing cost.

By 1920, pigment-coated paper was a commercial commodity with estimated consumption in the United States of about 100,000 tons, or approximately 15% of total printing and writing paper. The printing fidelity and attractive appearance obtained with these pigment-coated papers gave them an aura of elegance that made them desirable for corporate annual reports and for brochures advertising high-priced items such as automobiles. Basis weights ranged from 90 to 150 g/m^2 (60–100 lb per book ream) with most production falling in the middle of the range. The dominant pigment was coating clay (kaolin) imported from England, and the common binder was animal glue. Until 1909, almost all paper coating clays were shipped from England into the United States. The strikes in the British kaolin industry in 1909 helped to spur the development of coating kaolin in the United States [4].

During the 1930s, a number of developments combined to produce a marked increase in the demand for pigment-coated paper. The application of coating on the paper machine, rather than as a separate operation, greatly reduced the cost of producing pigment-coated paper. The invention of highspeed heat-set letterpresses made high-volume, low-cost printing a reality. Together these developments made possible the high-volume graphic periodicals such as *Life* and *Fortune*. In 1935, pigment-coated paper consumption in the United States approximated 250,000 tons. Fifteen years later, despite a 5-year plateau dictated by World War II, pigment-coated paper volume had quadrupled, top-

ping 1 million tons in 1950. During the 1950s and 1960s, technical advances in coating materials and equipment fostered continuing growth. By 1970, pigment-coated paper demand in the United States reached 3,275,000 tons, a fourteen-fold increase in 35 years, which is equivalent to a growth rate of 8% compounded annually. If a correction is applied for the substantial lowering in average basis weight during this period, the coated surface area available for printing increased at a rate in excess of 10% yearly. A graphic illustration of the general relationship between the introduction of new technology and the increase in coated paper volume is shown in **Figure 1.1**. In the 1990s and 2000s, significant technology improvements were made and production continued to increase. Much of the new technology was developed to improve machine efficiency in lightweight coated papers through the development of film coating as well as improved application techniques for paperboard and specialty papers. Improvements included jet-applicator coating to replace applicator-roll coaters and curtain coating to replace air-knife coaters.

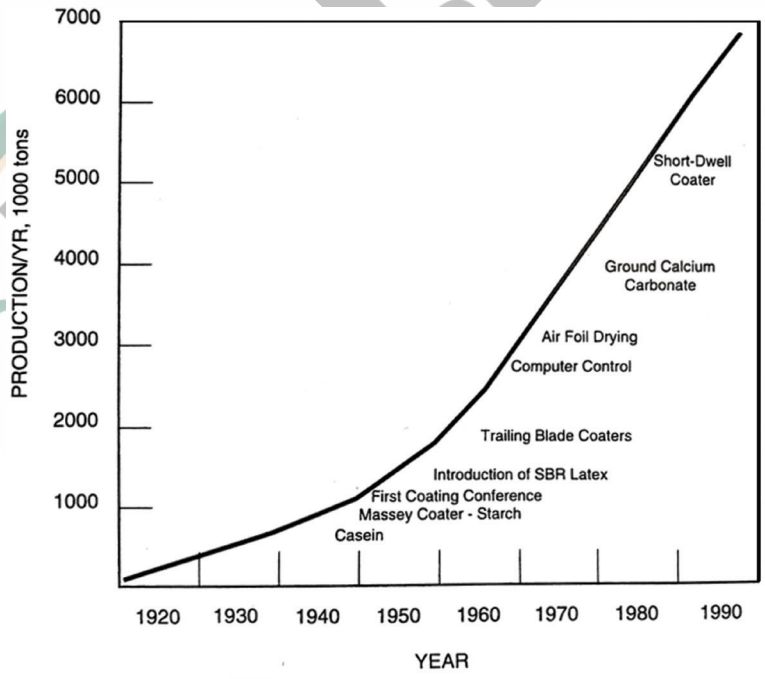

FIGURE 1.1. *The impact of new technology on coated paper.*

GLOBAL PAPER AND PAPERBOARD PRODUCTION

About 516 million metric tons of paper and paperboard were produced globally in 2022 with China, the United States, India and Japan being the four largest paper producing countries, accounting for 166, 72, 28 and 27 million metric tons, respectively [5]. The current (2022) packaging paper and paperboard category (coated and uncoated) accounts for >65% of the total global paper production, followed by printing and writing (P&W) paper at 16% (coated 5% and uncoated 11%). The tissue, specialties, and newsprint grades comprise 11%, 5%, and 3%, respectively (**Table 1.1**). Some of the examples of specialty grades include paper used for art, cigarette, hygiene, lamination, wall lining and construction. As shown, market share of the packaging paper and paperboard and tissue grades increased significantly from 2007 to 2022 while P&W paper and newsprint declined precipitously.

Unlike globally, the production of paper and paperboard in North America is declining: 89.7 million metric tons in 2012 to 81.8 million metric tons in 2022 (**Figure 1.2**) [5]. Figure 1.2 shows the growth or decline in the production of various types of paper and paperboard in North America. It is clear that the production of containerboard board grew while graphic paper (P&W and newsprint) declined rapidly

TABLE 1.1. Global Production of Paper and Paperboard [Source: FisherSolve®, © 2023 Fisher International].

	Year 2007		Year 2022	
Paper/Board Grades	**Metric Tons**	**%**	**Metric Tons**	**%**
Containerboard	130,732,287	33.1	235,836,757	45.7
Cartonboard	56,427,405	14.3	86,995,180	16.9
UnCoated free sheet	47,224,307	12.0	44,432,302	8.6
Newsprint	42,749,569	10.8	15,871,406	3.1
Coated free sheet	28,120,924	7.1	17,438,107	3.4
Tissue	26,539,198	6.7	57,234,150	11.1
Specialties	19,780,438	5.0	25,165,511	4.9
Coated Groundwood	16,828,608	4.3	8,410,051	1.6
Uncoated Groundwood	14,489,818	3.7	11,145,220	2.2
Packaging Papers	11,484,324	2.9	13,294,600	2.6
Total	**394,376,879**	**100.0**	**515,823,283**	**100.0**

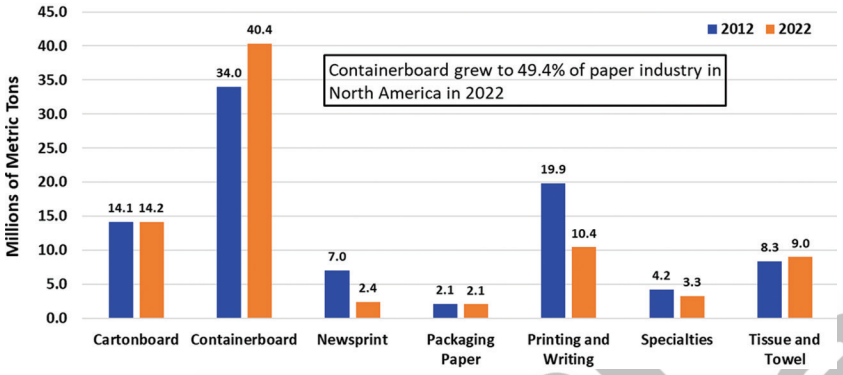

FIGURE 1.2. Total paper and paperboard production in the North America in 2012 versus 2022 [Source: FisherSolve®, © 2023 Fisher International].

within a decade. The coated P&W paper and coated board are further compared for 2012 and 2022 in **Figure 1.3**. The figure shows that the Coated free sheet and groundwood paper production and their market shares declined while the share of the coated cartonboard (boxboard) increased significantly. Coated linerboard comprises a minute fraction of the market which also declined from 2012 to 2022.

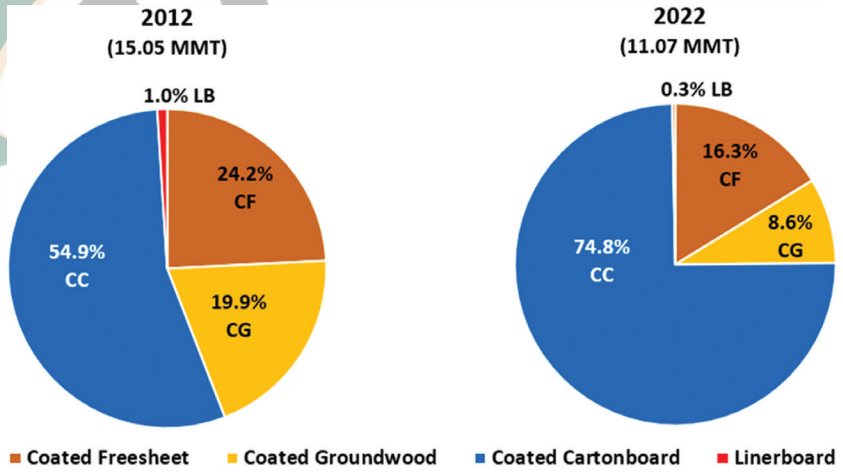

FIGURE 1.3. U.S. distribution of coated printing/writing paper and coated board (CF = Coated free sheet; CG = coated groundwood; CC =cartonboard; LB = linerboard) [Source: FisherSolve®, © 2023 Fisher International].

COATED PAPER AND PAPERBOARD (P&B) GRADES

There is no clear delineation between paper and paperboard. However, one of the main distinguishing features between them is grammage, or basis weight, which can also overlap. Generally, paper is lighter with basis weight of <170 g/m^2 whereas paperboard is heavier with a basis weight of >125 g/m^2. Certain linerboard used for small boxes can have basis weight <100 g/m^2 [6,7].

Paper and paperboard are classified in many ways, such as by pulping method (mechanical/groundwood or chemical pulp), brightness, basis weight (lightweight, medium weight, or heavy weight coated), or final market place use (cartonboard or containerboard).

Coated Paper (P&W)

Coated P&W papers are used for magazines, catalogs, brochures, direct mail, annual reports, and labels. There are many different grades of coated P&W paper, and grades can vary from region to region, such as North America, Europe, or Japan. The two fundamental classifications are coated one side (C1S) and coated two side (C2S). The C1S papers are used primarily for labels, wrappings, and the like where only the coated surface is printed. For the United States, the volume of C1S paper represents a very small amount (<6%) of total coated paper production. The coated paper is also divided into six grade categories based on brightness and fiber furnish (**Table 1.2**). Premium is the brightest and contains predominantly chemical (woodfree or freesheet) fiber whereas No. 5 is the least bright and includes a large percentage of groundwood or mechanical pulp. Mechanical or groundwood paper is manufactured using wood pulp that is mechanically ground and has not been cooked or chemically treated. In mechanical pulping, most of the wood components (e.g., lignin) is still present in the pulp and therefore the paper made from mechanical pulp is more prone to yellowing. Woodfree paper or freesheet is referred to as a paper created from chemical pulp rather than mechanical pulp. Chemical pulp is made of pulpwood and is not considered to be wood because the majority of the lignin is eliminated and extracted from cellulose fibers during processing. In woodfree paper, <10% mechanical pulp is used.

Mechanical papers, also called publication papers, are sold in rolls and used for magazines, catalogs, inserts, and direct mail and are both

TABLE 1.2. Grades of Publication Paper (North America).

Grade Level	Base Paper/Pulp Type	Paper Type	GE/TAPPI Brightness
Premium	Dominantly chemical pulp, <10% mechanical pulp	Coated free sheet (CFS)	≥88
No. 1	Dominantly chemical pulp, <10% mechanical pulp	Coated free sheet (CFS)	85–87.9
No. 2	Chemical pulp, <10% mechanical pulp	Coated free sheet (CFS)	83–84.9
No. 3	Chemical pulp, <10% mechanical pulp	Coated free sheet (CFS)	79–82.9
No. 4	Dominantly mechanical pulp, some chemical pulp	Coated groundwood/lightweight coated (LWC)	73–78.9
No. 5	Dominantly mechanical pulp, some chemical pulp	Coated groundwood/lightweight coated (LWC)	≤72.9

offset and rotogravure printed. Coated free sheets are predominantly heavier than mechanical papers and are used for brochures, annual reports, and expensive magazines and advertising. They are both web-offset and sheet-fed offset printed and are also called merchant grade.

In Europe, the primary classification is still based on the pulping method of the main fiber component: dominantly mechanical pulp paper (mechanical printing paper) and dominantly chemical pulp paper (woodfree printing paper). These are further classified based on coat weight or grammage, such as ultralight weight coated (ULWC), lightweight coated (LWC), medium weight coated (MWC), high weight coated (HWC), standard fine paper, light coat weight fine paper, and art paper (**Table 1.3**) [6,8]. In some instances, coated papers are also classified based on the type of machinery used, such as machine finished coated (MFC) and film coated offset (FCO).

Figure 1.4 shows the product types produced from different coated paper and paper board grades based on European classification and their relative value [8].

In Japan, coated paper is classified based on dominating pulp type (A = chemical or B = mechanical) followed by a numerical value designating the amount of coating (1 = heavy coat weight, triple coated; 2 = medium, double coated; and 3 = light coated, single coated). For example, "Coated A3" refers to woodfree light coated [8].