

Functional Corrugated Board with Organic and Inorganic Materials in Food Packaging Applications: A Review

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Abstract Corrugated board provides packaging for most diverse industries with a share of over 50%, due to the numerous advantages they offer a good protection of the products. In other hand corrugated board fails in environmental conditions, indicating that relative humidity or temperature is higher. These effects directly damage the product packaged. To overcome on this problem recently corrugated boards produced with functional material, “functional corrugated boards,” have become more available in the current market. A number of commercialized forms of functional material are coated or composited products with inorganic materials, for example “Nano clay” as representative. However, although the use of functional materials is increasing in corrugated boards, the several concerns such as over cost, environmental friendly materials, recycling, and toxicity affect consumer perceptions and acceptance. In the past, number of researcher focused on process of box compression and the utility of box compression testing etc., best of our knowledge there is no review paper which focus on the functional corrugated boards used in food packaging applications. This paper aims to review the availability of functional corrugated boards in the current market, past research studies on functional material and present the current status of functional corrugated boards in leading countries.

Keywords Corrugated boards, Packaging, Functional material, Food packaging

Introduction

Corrugated board is a primary material in the shipping, distribution and storage of almost every product. Corrugated fiberboard packages provide products with temporary protection against damaging forces at all phases of the distribution process¹⁾. It is also good to know that the range of corrugated board provides packaging for most diverse industries with a share of over 50%, due to the numerous advantages. Corrugated board is light in weight and also protects products from against they offer a good protection of the products due to the capability to take over the mechanical stress by the corrugated layers. The production cost is lower than those of other packing categories and they can be transported folded, which are suitable for transportation using pallets, can be reused and are biodegradable. In terms of creativity and aspect they may be simple or complex and perhaps the most important of all is that they can be printed and customized. This property makes the material the best choice to produce containers devoted to the shipping of goods²⁾.

Paper and paperboard have been increasingly used as a packaging material since they are renewable, recyclable and biodegradable. More than 2.5 million tons of paper and paperboard are used worldwide in food packaging³⁾. However, food packed in paper and paperboard can be contaminated with microorganisms such as *Bacillus cereus* or *Escherichia coli* by adding active antimicrobial agent in corrugated boards which can protect food product from spoilage. At present, antimicrobial packaging materials are being developed to solve many problems associated with food distribution and safety. In fact, antimicrobial packaging is considered as active packaging that can be defined as a mode of packaging in which the package, the product and the environment interact to prolong shelf life or enhance safety or sensory properties, while maintaining the quality of the product⁴⁾.

Technological developments currently influencing the corrugated board packaging industry include an increase in the use of bio-polymers and different functional material. These performances help to enhance the properties of corrugated board, graphics printed on the cardboard as well as the quality of barrier coatings in packaging used for food products and other consumables. The environmental impact of using these products is low because they can be easily recycled. This result has helped to boost its popularity.

Function material having certain designed properties for

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specified application has to be able to control the selected properties. As examples of end applications using functional materials, because paper is highly sensitive to moisture, if using functional material which has good moisture barrier properties, so we can protect our packaging by adding this material. Intentionally, functional materials may come from two sources; naturally occurring or engineered material sources. These materials are distinctly different from structural materials. Their physical and chemical properties are sensitive to a change in the environment such as temperature, pressure, electric field, magnetic field, optical wavelength, adsorbed gas molecules and the pH value. The functional materials utilize the native properties and functions of their own to achieve an intelligent action. Functional materials cover a broader range of materials than the smart materials⁵⁾. Functional materials cover a wide range of organic and inorganic materials. This study focuses only on functional materials use in corrugated boards. Preparations of complex oxides with functionality are a key challenge for materials development. Searching new routes to prepare materials and understanding the relationship between the structures and the properties are equally important. A key requirement in preparations of materials is to control the structural and compositional evolution for achieving superior properties. "Soft chemistry" has shown a great success in fabricating functional and nano phase materials. Nano-crystal engineered materials are a new trend of materials research, aiming to improve the performances of materials by several orders of magnitudes⁵⁾. Example of functional materials, silica hybrid with corrugated cardboard. It is used for the preservation of this products. When we incorporate the functional materials in to the corrugated boards the corrugated cardboard we don't need different production and processing line since the method of production of functional corrugated boards is same. Role of silica hybrid is preservation of the lining of cardboard to absorb ethylene gas containing nano-powder. Nano-powder is made of white silica as raw materials to the main components of the porous silica-based powder, as white silica for the adsorption properties of ethylene gas than carbon, zirconium and rare earth zeolite to be good, so white silica powder with nanometer of paper inside the corrugated cardboard mount as more good preservation effect.

Functional corrugated board is important for packaging of fresh produce preservation, packaging containers for temperature humidity and air control and other environmental conditions. For example, in case of fresh fruit and vegetable packaging antimicrobial corrugate boards can help to maintain their quality. By maintaining an appropriate temperature we can reduce water evaporation from the food products. The contents of naturally emit ethylene gas can be eliminate suppression of aging. In addition, another important reason for preserving fruit and vegetables is due to contamination of pathogenic microorganisms. It can lead to many harmful

effects causing fruits and vegetables withered and corrupt. Antibacterial corrugated cardboard is deposited in a layer of surface mount nano anti-bacterial preservatives. This does not affect the corrosion of the food hygiene. Similar approach we can apply in electronic good, or any other industries. These industries are looking for functional corrugated boards as a replacement for regular corrugated boards.

This review article will focus on the available research from the references of previous studies on the application of functional materials in the corrugated boards for packaging application. The recent development of commercialized corrugated boards with functional materials is also discussed.

Functional Materials

Until the present, large number of materials have been introduced for corrugated board packaging as functional additives including chitosan, silver nanoparticle, nano-clay, whey protein isolate, silica, nano-titanium dioxide, zeolite and many more^{6,7)}. Due to differences in chemical structure and characteristics, each material introduces distinct properties to the host material, which lead to different functional packaging applications⁸⁾.

Chitosan

Chitosan has good antimicrobial properties. Chitosan is a linear polysaccharide derived from chitin, a major component of crustacean and insect shells. Despite that paper and chitosan are two materials widely studied independently for food packaging applications, only a few works dealt with paper coated with chitosan based materials show that chitosan decreased paper resistance to water or vapor transfer⁹⁾.

Nano clay

Clay has a good moisture barrier property. The clay based coating forms a less porous surface allowing a thinner application of polymer top coat resulting in a higher water resistance at a given thin coat weight. The increase in strength is attributed to the high modulus of clay compared to polymer^{10,30)}.

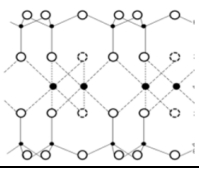
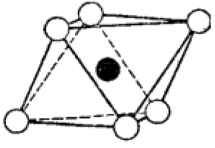
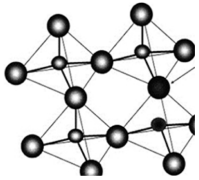
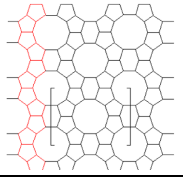
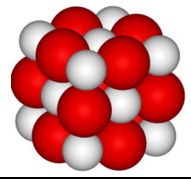
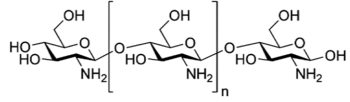
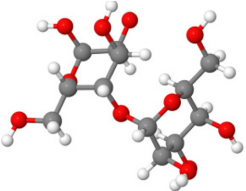
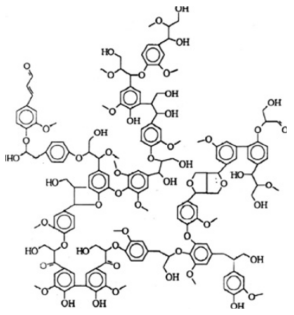
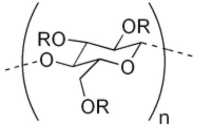
Whey protein isolate (WPI)

WPI coating on paper increased the property of ink printability, and reduced water-vapor permeability of the paper. General properties include mechanical properties such as tensile properties, tearing strength, and burst strength, optical properties for color and gloss, and grease resistance¹¹⁾.

Zeolite

Material can be effective as an ethylene scavenger to prolong the shelf-life of fresh fruits when packing into the corrugated box¹²⁾.

Table 1. Examples of several functional material candidates for packaging applications

Inorganic materials	Type	Structures	Main function	Application
Montmorillonite (Natural clay)	Inorganic		Moisture scavenger	Dry food products like cereals, crackers etc.
Bentonite	Inorganic		Ethylene absorber	Fresh fruits
Zeolite	Inorganic		Antimicrobial, Ethylene scavenger	Meat and meat products, fresh fruits
Silica	Inorganic		High barrier	Moisture and oxygen sensitive food products
Calcium oxide,	Inorganic		Moisture barrier	Dryfood products
Chitosan	Organic		Antimicrobial	Meat, fish, fresh fruits and vegetables
Whey protein isolate	Organic		Improve the property of ink printability, & reduce water-vapor permeability	Products where attractive printing required, dry products
Lignin	Organic		Barrier to moisture	Dry food products
Carboxymethyl cellulose	Organic		Improve mechanic properties, decrease water permeability	Dry food products

Recent Studies on Functional Corrugated Boards

Over the last few years, several studies have reported the application of functional material into a corrugated board. Jo *et al.*¹³⁾, investigate the effectiveness of chemicals treatments on top liner surface and insolubilization of starch adhesives to improve the water-resistant performance and mechanical properties of corrugated board boxes for agricultural products in the cold chain system. Strength of the board increased by surface chemical treatment up to 60% of compressive strength and 30% of bursting strength. Hult *et al.*¹⁴⁾, reported commercially available softwood lignin was esterified with tall oil fatty acid (TOFA) and studied as barrier material in fiber-based packaging material. The lignin was esterified to different degrees of substitution. Commercially available lignin (Indulin AT) esterified with tall oil fatty acid to different degree of substitution and tested for barrier application in fiber-based packaging materials. Paperboards coated with TOFA lignin esters showed a significant reduction in water vapor transmission rate and oxygen transmission rate. The novel TOFA lignin ester coating materials can potentially be exploited as sustainable barrier material, thereby replacing the conventional petroleum based barrier material.

Akrami *et al.*¹⁵⁾, investigated the antimicrobial and antioxidant properties for packaging paper. Iranian Zataria and European cumin have been studied as antioxidant and/or antimicrobial agents in active paper for food packaging. Among them the most efficient as both antioxidant and antimicrobial was Zataria. Cumin showed lower antioxidant properties and not enough antimicrobial performance to inhibit *in vitro* the common pathogens. Lee *et al.*¹⁶⁾, reported antibacterial property and freshness maintenance of functional hybrid corrugated board used for agricultural products. Hassan *et al.*¹⁷⁾, reported, olive stones wastes were used to prepare cellulose nanocrystals (CNC) and carboxymethyl cellulose (CMC). Presence of CNC in the coating mixtures resulted in improving mechanical properties and decreasing water absorption and air permeability of paper sheets as compared to paper sheets coated with neat CMC coating mixture. Zhu *et al.*¹⁸⁾, investigated, a dielectric nano composite paper with layered boron nitride (BN) Nano sheets wired by one-dimensional (1D) Nano fibrillated cellulose (NFC) that has superior thermal and mechanical properties. These nano composite papers are fabricated from a filtration of BN and NFC suspensions, in which NFC is used as a stabilizer to stabilize BN nano sheet. In these nano composite papers, two-dimensional (2D) Nano sheets form a thermally conductive network, while 1D NFC provides mechanical strength.

Vanit *et al.*¹⁹⁾, reported, on developing antimicrobial coating solutions for paperboard containing a natural plant extract clove oil (*Syzygium aromaticum*) in a modified hydrophobic starch

matrix. Pure clove oil showed a minimum inhibitory concentration (MIC) of 1.25% against the growth of *Escherichia coli* while the MIC for the other two bacteria (*Bacillus cereus* and *Staphylococcus aureus*) was at 2.5%. In addition, a coating solution containing clove oil in 8% hydrophobic starch matrix showed better inhibiting effect than in 5% hydrophobic starch matrix over all types of bacteria with the MICs similar to pure clove oil solution at 1.25% for *Escherichia coli* and at 2.5% for *Bacillus cereus* and *Staphylococcus aureus*.

As per Wang *et al.*²⁰⁾, the antimicrobial activity of corrugated board coated with oregano oil was studied. Oregano oil, chitosan and β -cyclodextrin were compounded into blended liquid and coated onto surface of corrugated board and the fumigating antimicrobial activity of corrugated board to penicillium, pythium, alternaria and gray mold was studied in a series of coating weight of oregano oil. The result showed that the antimicrobial activity of corrugated board is increased with the increase in coating weight of oregano oil, and corrugated board can fully inhibit the four kinds of fungi when the coating weight of oregano oil is greater than 3.04 g/m². Showers Robert James²¹⁾, investigated, industrially prefabricated corrugated stock to include although not limited to corrugated cardboard for the purpose of forming boxes, cartons, or for packaging hot, cold and/or perishable items. The components making up the corrugated board design are first laminated with polymer-based Aerogel film that is extremely flexible, extremely strong (durable), fireproof, waterproof, hydrophobic as well as super-insulating. Cavities are filled with an insertable/injectable insulation. Once components are laminated with said Aerogel polymer-based film on all main surfaces, these components are next assembled into corrugated stock that soon afterwards is used to form boxes, cartons and, or packaging.

Lee, Chuko²²⁾, investigated to provide a container made of a plastic corrugated board which exhibits an antibacterial and deodorizing effect for a long period. It can be used without anxiety in the food product industry and the medical supply industry. This can also exhibit an antistatic effect using nano-silver material in this study. Plastic corrugated board is molded by an arrangement where the face made of the plastic molding material mixed with the compressed nano-silver material is positioned on the inner face of the container. Lee & Sun²³⁾, introduced the waterproof corrugated cardboard box for the efficient shipment of Chinese cabbages and radishes.

Lee *et al.*²⁴⁾, studied a new antibacterial material, a non-woven fabric, a sulfur solution, and a new adhesive system to manufacture a new type of functional hybrid corrugated board. The functional hybrid corrugated board could be manufactured in the actual process with linerboards, non-woven fabrics, and other materials without any troubles, and was strong enough to be used as a packaging box for agricultural products. The antibacterial property of the hybrid corrugated board showed a value high enough to eliminate bacteria, which could

Table 2. Examples of currently available functional corrugated board for food packaging in the market

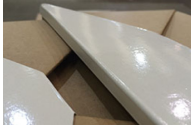











Type	Functions for packaging application	Target products	Samples (Image)
Moisture barrier	Prevent corrugated board from humidity/moisture	Dry food products	 Siliconpack Ltd., Alfreton, UK
Freshness maintenance	Ability to remove undesirable gas and maintain excellent freshness	Suitable for agro and marine products like fruits, vegetable, flowers	 Kalos Corporation, Seoul, Korea
Oxygen barrier	Addition of oxygen barrier to the desired substrate	Oxygen sensitive food product	 Paramelt, USA
Cold storage/ Freshness retention	Corrugated boards coated bottom liner for cool insulation	Ideal for the refrigerated transport of items such as fruit and vegetables, processed marine and meat products, and alcoholic beverages	 Rengo Co. Ltd., Japan
Water resistance	High level of resistance to water, comparable to wax dipped corrugated packaging, also a high level of recyclability	Use full in dry products packaging	 Werner Kenkel
Green pack	Ethylene elimination and gas composition control help to ensure that fruit and vegetable remain fresh	Packaging of fresh produce	 MoistTech Corp.
Insect-resistant	A special mixture of ink and varnish coating on corrugated boards repels insects, discouraging them from entering the box	Packaging of food products	 Rengo Co. Ltd., Japan
Oil and grease resistance	It offers no-stain solution to protect your products from virtually every source of oil and grease	Packaging of bakery, dry goods, frozen meats, and food oils	 Moore packaging corporation, USA

Table 2. Examples of currently available functional corrugated board for food packaging in the market (Continued)

Type	Functions for packaging application	Target products	Samples (Image)
Functional and attractive	It fulfills the demand of demands on the transportation and presentation which primarily protect the content from breakage and attractive design	Wine packaging	 Rondo Ganahl AG
Coated corrugations	Coated corrugations prevent condensation from penetrating into the paper and guarantee good stability	Packaging of fresh produce	 Rondo Ganahl AG
Impact resistance	Suspended trays to protect berries from impact	Berries packaging	
Environmentally friendly	Boxes are environmentally friendly because they do not require staples or tape for sealing	Any kind of food	
Antirust corrugated	Corrugated packaging with special coating to prevent rust on metallic surfaces. Ideal for inhibiting rust formation on cans contains food	Cans use in food packaging	 Shenyang rust proof packaging material Co. Ltd., China
Abrasion resistance	Abrasive resistant coatings keep products from scuffing and preserve graphics and other package information.	Packaging of high cost product (important when maintaining your brand's image during shipping and distribution)	Cascades Sonoco, USA
Anti-slip	Not easily affected by environmental changes, this cardboard provides stable anti-slip functionality	Layer pads and fitments, Palletized loads, Point of sale display packaging	 Smurfit Kappa Packaging Product Ltd., UK

deteriorate the sweet persimmons. Based on appearance observations, weight loss and firmness measurements, the freshness of sweet persimmons in the functional hybrid corrugated board was maintained better than that in the conventional corrugated board.

Use of Nanotechnology in Functional Corrugated Board

Carton packaging in nanotechnology nanomaterials with

sensitivities of temperature, gas, and humidity has potential applications in anti-counterfeit packaging boxes to be used and developed. The sensitivity of nano-particles can be used for preparing the temperature (heat) sensitive materials or humidity-sensitive material, and then used as anti-counterfeiting packaging carton²⁶. Metal particles are generally black materials with infrared absorption characteristics, large surface area, high surface activity, and sensitive to the surrounding environment (temperature, heat, light, humidity, etc.). Therefore, the nano-particles with these features by adding packing mate-

rials can be used by painting or polishing the surface coating on the packaging materials. To achieve security purposes, the consumers will choose the packaged products are identified through the heat, light or temperature. The physical and chemical effects of security and other purposes may improve the advanced anti-counterfeiting technology using nanotechnology.

Nano-preservation materials

Nano-preservation materials affect to increase the quality changes of fresh produce and other fresh processed food, and directly extend their shelf life. For packaging application, the ethylene gas generated by the fruit and vegetable reaches a certain concentration which accelerate the decay rate of decay on their products. To solve this problem, one of preservation methods for the package should seek a proper ethylene scavenger to reduce the level of ethylene content in the package, but the effect of ethylene absorbent currently using is not ideal. The application of nanotechnology may solve this problem for removing the undesirable gas contents. With nano-silver powder as an efficient catalyst of ethylene oxidation by adding silver nanoparticles in the packaging material, it can accelerate the oxidation of ethylene released from fruit and vegetable. This can be achieved a good preservation effect. In addition, tissue paper corrugated box manufacturing process may be added nano-porous ethylene gas absorbing powders to prevent ripening. Nano-absorbent silica powder is used as the white silica as a main component of the porous powder. Since the white silica has a good ethylene gas adsorption capacity compared to that of carbon, zirconium and rare earth zeolite, the nano-white silica powder added in a sheet of corrugated board has shown a better preservation effect²⁵).

Nano-ink

As for the packaging and printing quality requirements continue to increase, customer demands not only a good quality to meet the special needs of a variety of environment protection, security, etc., but also high qualified ink property. Purity and fineness of the ink has a great influence on the quality of the product packaging. To print a high-quality packaging products, it must use a good guaranteed ink which has fineness and high purity properties. The nature and size of the filler particles have a direct relationship to the pigment of ink which reflects to the quality of packaging products²⁷). Research indicates that at nano- semiconductor particle surface, the medium surrounding the particles after chemical modification can strongly affect their optical properties and absorption spectra which shows a red shift or blue shift.

Nano adhesives and sealants

Adhesives and sealants are important products in a wide range of the corrugated packaging industry. Nano sealing adhesive strength, shear strength and heat resistance, and other phy-

sical and chemical indicators aging 50-70 nm after adding rubber particles formed in the resin are significantly improved over conventional adhesive, thereby greatly reducing the package and product usage. SiO₂ additive for adhesives and sealants can affect the adhesive bonding and sealing. Adhesive sealing performance is greatly improved as an additive added.

Nano UV varnish

Nano-particles can increase a gloss varnish to protect the printed surface for improving print abrasion resistance, chemical resistance, and water resistance. It can also prevent print rub dirty or adhesions. For paper plastic trays packaging products, shiny surface treatment technology is gradually developing towards the directions of UV curing, UV coating, and UV varnishing processes to make nanoscale color corrugated boxes with abrasion resistance, scratch means, moisture, and high gloss properties. Nano UV Varnish is mainly composed of nano-oligomer, reactive diluents, the composition of the light initiator and other additives.

Commercialized Functional Corrugated Boards in the Market

Kalos Corporation's, Seoul, South Korea based is a major manufacturer of functional corrugated boards. "KALOS" is a new material developed successfully by Kalos Corporation for the first time in the world with natural non-metallic minerals using nano technology and is applied in various products including starch fused glue, food freshness keeping material, harmful gas absorbent, and natural moisture remover. KALOS is an environment-friendly nano product used for keeping the freshness of various foods, removing moisture in the foods, and extending the sell-by-date. Their commercialized product includes, KALOS Corrugated Cardboard, KALOS powder fused with starch is used to make freshness and super-power solidity keeping high-functional corrugated cardboards. Sing-Sing Nano Box, KALOS corrugated cardboard is used to make high-functional corrugated boxes for fresh foods to keep freshness and remove harmful ingredients such as agricultural chemical residues.

Rengo Co ltd Japan, Rengo was the first company in Japan to become involved in the corrugated business. Their commercialized product includes, "High New Rencoat" low to medium water resistance, (high water resistance) "Recycool" used for cold storage/freshness retention, "BUGLESS" protect from insects enter into package, Green pack to maintain fresh ness in harvested fresh vegetable and fruit.

Cortec Corporation, USA, "EcoShield" Barrier Coating is a water borne barrier coating that is recyclable and 100% repulpable, effectively eliminate the need to use traditional wax and polyethylene papers. In addition, the coating can be utilized on kraft and recycled paper to seal the surface from contaminants

that could cause corrosion. The combination of a contaminant sealant and a repulpable coating for Kraft paper makes EcoShield Barrier Coating a pioneer in the packaging industry. This material can also be used as a coating on liners for corrugated boxes providing a water proof moisture barrier. EcoShield Barrier Coating also gives excellent oil and grease resistance.

DS Smith specialty packaging, England, has worked closely with salmon farmers to create a corrugated alternative to ice-filled, pre-formed polystyrene (PS) trays. “Silver King”, is a patented product that is delivered flat and can be hand or machine-erected to give a leak-proof base tray with moisture-proof lid. A heat-reflective liner is used for the outer corrugated section, while a water-resistant liner coats the inside. A fanfold corner and lock-over flaps arrangement makes the tray leak-proof, and tests conducted over a 12-hour period show the system maintains temperatures eight per cent lower than expanded PS options. Waterproof inks can also be used on the outer reflective surface to give multi-color branding opportunities. The new system has seen a 20 per cent reduction in basic packaging costs, due to receiving the pack in the flat and reusing the delivery pallets. It has also been possible to reduce the height of the container, giving an increased unitized loading density and a saving of eight per cent in distribution costs.

Green Light a pallet company, USA, made 100% recyclable and reusable paper pallet is made of 100% corrugated fiberboard, thereby eliminating the use of wood. It significantly reduces cost and pollution in its production, and does not require the fumigation which wooden pallets must undergo to kill any insects. It is one-third of the weight of wooden pallets and could be mass produced to any specified shape or size. Compared to a wooden pallet, it is safe and hygienic as it does

not splinter or use nails or screws for construction.

Amtor, Australia, developed “Chill fresh” pack, from recycled paper fiber and functional film laminate recently developed by Amtor functional coatings and known as Thermshield™, which combine to produce a light weight environmentally friendly corrugated material solution. Amtor ChillFresh™ due to its construction allows for better shelf utilization, has a clean sterile appearance and eliminates the problem of loose foam particles being left in the inner contents of the pack.

Current market status

The global corrugated packaging market is expected to grow at a compound annual growth rate of 4.0% during 2014 to 2020, to reach an estimated US\$173.6 million by 2020, according to Persistence Market Research²⁸. As shown in Fig. 1, the global corrugated packaging demand at current year is represented. The corrugated packaging market is thriving mainly due to growing end-user industries including food, medicine, consumer durables, rubber, and petroleum. Benefits associated with corrugated packaging such as sustainability and low cost makes it one of the preferred modes of packaging across various industries. Emerging markets offer growth opportunities for the corrugated packaging market due to increasing population and growing demand for consumer products in these regions.

Growing markets

The continued migration to the cities of the population in every country is causing more activity in the construction industry through investment in housing. Increased disposable income in Asia countries is driving consumption of household items and white goods such as refrigerators and washing ma-

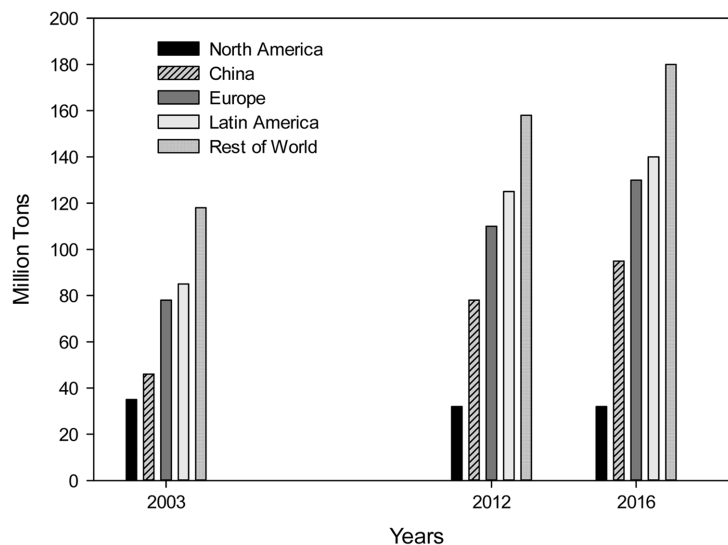


Fig. 1. Global corrugated packaging demand (Source²⁹: RISI world containerboard forecast Dec 2012).

chines. The healthcare sector is growing, particularly in developing countries, and increasing the need for rigid corrugated cardboard packaging for the secure transportation of medicines and medical equipment. Import and export markets are being fueled by heated demand for luxury items from the east, including cheap wines from California, South Africa and Australia, chocolates from Switzerland and out-of-season fruits from South America. Corrugated cardboard packaging is in high demand in the processed food sector, as well as industries such as household and personal care, electrical goods, and chemicals. The home and office relocation industry has become fully commercialized over the past two decades, and with thousands of people and businesses relocating globally each year, the sale of new moving boxes has quadrupled.

International market

North America is the largest market for corrugated board packaging followed by Europe. Asia-Pacific market is expected to witness better growth rate due to increasing growth in the end-user industries in countries such as China and India. In last few years there is a significant growth in consumption of corrugated box in Asia by processed food industry, fruits & vegetables suppliers, electronic industry and consumer durable goods industry.

An increase in retail sector along with demand for ready to eat food items is expected to increase the demand for better packaging material. This will provide plenty of opportunity for growth in the global corrugated board packaging market. Additionally, increasing internet shopping is also expected to increase the overall demand for corrugated board packaging. Growing industrial activities, particularly in the manufacturing sector, requiring better packaging techniques to protect and transport goods are also expected to drive the global corrugated board packaging market. Increasing industrialization and expanding international trade in the developing countries are expected to increase the market growth. Environmental concerns also acts as a driving force for the overall market. Requirement for environment friendly packaging material such as, corrugated boards which are degradable in nature would also increase the demand for corrugated board packaging technique.

Asian market

The packaging industry in South Korea was valued at KRW 12, 058.7 billion in 2014. Paper and board packaging constitutes the largest market share by value, followed by plastics, metal, and glass packaging. Paper and Board packaging holds the largest share of the packaging industry valued at KRW 5,021 billion.

According to China's macroeconomic development and the paper and packaging industry's development trends, it is expected that between 2005 and 2015, China's paper and paper-

board demand, will go from 1022.92 (USD) in 2005 to 1368.9 in 2010 to 1747.1 (USD) in 2015. The corrugated packaging industry still has much room for development in the coming decade. Packaging materials and systems are the keys to reducing total cost so the global corrugated carton industry must face up to the problem of how to effectively control production costs and provide customers with comprehensive services. Competition in global corrugated packaging focuses on the economic costs of carton enterprises. Lightweight, quantification, resource saving and cost-reduction of corrugated carton is an outcome of scientific and technological development and a significant contribution to society's prosperity and it is undoubtedly the future of corrugated carton.

Conclusion

Corrugated board industry has grown significantly from the long history of research performed on corrugated paperboard. Industry researchers, scientists, academia have developed a robust understanding of moisture interactions with paper materials and have a fundamental basis for testing those materials. They've refined good first-principle models for estimating box strength and can reasonably predict the performance of a package in a typical use environment. They also have some initial estimations of how the environmental factors affect container requirements. Functional material is a one option in the corrugated boards so that we can achieve our need depend on which product is going package. Now a day there is increasing market trend of functional corrugated boards. Also, packaging manufacturer concerns over possible increase in cost of corrugated boards and environmental factor regarding recycling of corrugated boards. Keep in mind these concerns in research in future should be done on environmental friendly material, bio composite material, use of organic material as functional material in corrugated boards and the cost of material.

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