

Potential of Paper Coating with Palm-based Materials for Food Wrappers

□ Abdul Rashid, A S; Ooi, T L
and Salmiah Ahmad



Most of the coating and plastic materials used in food packaging industry are derived from petroleum and natural gas such as paraffin wax, microcrystalline wax, polyethylene, polypropylene, *etc.* These materials are from non-renewable resources and with the rapid increase in the price of petroleum and natural gas, it may be necessary to take a new look at the renewable resources of vegetable oils and their derivatives as starting or supplementary materials for plastics or coatings in food packaging industry.

Owing to the increase in world production of palm oil in Asia and Africa, soybean in Brazil and concerns about the environment and toxicity, materials

derived from vegetable oils may offer suitable substitutes in the food packaging industry. Paraffin wax coated paper for wrapping foods dated from about 1866 and hence this is one of the oldest hot melt coating processes (Casey, 1980). Paraffin wax is a mixture of straight chain saturated hydrocarbons. It has the advantage of being relatively inexpensive compared to synthetic polymers and resins and has further advantages of low melting point, low viscosity and capability to produce films that are hard, glossy, non-tacky, heat sealing and water-vapour resistant.

Microcrystalline waxes were first introduced in 1927, and since then they have supplemented paraffin wax for many uses such as to improve the film or coating

on the paper. These waxes are obtained from the heavy lubricating oils after the solvent refining of paraffin oil. These materials have much finer crystal than paraffin wax. Microcrystalline wax is composed entirely of hydrocarbons, some of which are branched-chains while others are aromatic. This wax has high molecular weight, melting points (65°C – 100°C) and high viscosity in the molten state.

Microcrystalline wax is not hard enough to be used by itself for most coating purposes. It is often used in combination with paraffin wax and resins to increase the flexibility and toughness of the film. The film or coating properties were further improved by blending the wax with resins and synthetic or natural polymers such as ethyl cellulose, polyethylene, and co-polymer such as polyethylene vinyl acrylate. For example, ethyl cellulose is the first polymer to be used successfully in hot melt coating formulations, in combination with paraffin wax and hydrogenated castor oil.

The synthetic polymers such as polyethylene and co-polymer polyethylene vinyl acrylate are introduced to lower the cost and further improve the coating or film properties. The use of paraffin and microcrystalline waxes that are petroleum-based materials are not encouraged in some countries because of their toxicological effect to the human health.

RECENT DEVELOPMENTS IN THE USE OF FATTY MATERIALS IN FOOD PACKAGING

Polymer films for food packaging have been prepared by esterifying straight chain fatty acids with alkaline oxide. Additives could be added to these mixtures to produce antifogging polymer films. The study had shown that no water droplet was observed for six months at 20°C.

There was no blooming after one day in water at 60°C and no change was observed after three months (Takashi Murakami *et al.*, 1978).

An extrudable compound for coating paper and paperboard packaging materials was prepared using a mixture of hydrogenated palm oil and gum. These materials are also suitable for coating paperboard containers (Causin, 1977).

A wrapping paper for fatty foods has also been produced, which is analogous to a paraffin-coated paper. This wrapping paper has the inner part coated with hardened lard and is oxidation resistant at room temperature (Mettler, 1992).

In addition, modified polymers for polymer films are prepared by reacting alkene C18-80 (polyethylene fraction) with α , β unsaturated dicarboxylic acids and/or derivatives, followed by reaction with unsaturated acrylic C12-36 carboxylic acids and/or plant oils, *e.g.* linseed oil have been reported (Hajek *et al.*, 1992).

COATING PROCESSES

There are several types of paper coating processes such as aqueous/solvent coating, extrusion coating and hot melt coating (Casey, 1980).

I) Aqueous/Solvent Coating Process

In this process, the coating formulation can be present in one of the two basic forms; dissolved in a solvent and as part of the continuous phase, or present in a discontinuous phase as latex or emulsion. Film formation in coating involves the change from a liquid to a solid state, which can be done by different methods including evaporation of the solvent from a polymer solution; evaporation of liquid and coalescence of the particles of an emulsion and cross linking or polymerization.

II) Extrusion Coating Process

The extrusion coating is the application of a hot, molten, diluent-free, high molecular weight polymer onto the surface of a moving paper substrate using an extruder die assembly. There are four steps involved in extrusion coatings. The polymer and sometimes the other ingredients are fed into an extruder to provide a homogeneous mixture. This mixture is metered at high pressure through a slot die to form a free film. The free film is drawn down to the desired thickness by the stretching effect of the substrate running and the film is combined with and pressed on the surface in a nip formed by a chilled metal roll and rubber-covered pressure roll.

III) Hot Melt Coating Process

The hot melt coating is the process of applying a solvent-free melt of wax, resin, or high molecular weight polymer, or mixture of these ingredients to the surface paper or other substrate. If the hot melt consists only of wax or a mixture of a wax with a resin or polymer, preparation is relatively easy. It involves heating in a simple heating and mixing system. The principal methods of hot melt coating are by roll-coater, slot-die coater, or curtain coater.

Hot melt offers several advantages compared with the solvent type coating which requires only coating to normal temperature suitable for food packaging. Coating operations of hot melt contains no volatile carriers and its preparation does not require special equipment to comply with environmental restrictions against release of volatile organic materials.

Machine-finished papers, super-calendered papers, pigment-(titanium

dioxide) coated papers, glassine and grease-proof are some of the grades used for waxing. The waxed products are used for bread wrappers, drinking cups, frozen food cartons, bottle-cap stock and paper milk cartons.

OLEOCHEMICALS INDUSTRY

Oleochemicals are chemicals derived from natural oils (edible and inedible) and fats. However, since 1985 the use of raw materials in oleochemical industry has changed dramatically. Palm oil (crude palm oil and palm kernel oil) which are biodegradable are now becoming increasingly important as the raw material. The production of basic oleochemicals in Malaysia is increasing rapidly. In 1992, 800 000 tonnes basic oleochemicals are produced and are expected to reach 1.2 million tonnes by the year 2000.

There are also synthetic oleochemicals derived from petrochemical derivatives such as propylene, ethylene and olefin. However, with the Green Revolution and as chemicals derived from petroleum and gases are not replenishable, emphasis has moved away from using petroleum products as inputs.

The applications or end uses of oleochemicals are very wide, for example in the area of cosmetics, lubricants, detergents, surfactants, plasticizers, alkyd resins, *etc.* and as reported 5% are being used in paper manufacturing industry for the purpose of water proofing (The Selected Industry Studies, 1993).

PALM-BASED OLEOCHEMICALS AS COATING MATERIALS

As mentioned earlier, paper coated with paraffin wax has been used in hot melt formulation for food wrappers. *Table 1* showed various types of paper coated with formulated paraffin wax based on ethyl cellulose and castor oil (Casey, 1980).

TABLE 1. VARIOUS TYPES OF PAPER COATING WITH FORMULATED PARAFFIN WAX, ETHYL CELLULOSE AND CASTOR OIL

Ingredients	High-Gloss Coating Shelf Paper	Heat-Seal Label Paper	Frozen Food Wrap	Hot Dip Process
Ethyl Cellulose	15 - 20	25	20	25
Paraffin Wax	9 - 25	15	20	-
Mineral Oil	-	-	-	64
Hydrogenated Castor Oil	5 - 8	24	20	-
Castor Oil	5 - 6	5	9	10
Resins	35 - 55	30	30	-
Antioxidant	1	1	1	1

Paper coated with various lipid materials such as fatty acid, fatty alcohol, RBD palm-stearin and hydrogenated RBD palm olein have been studied. Some properties of the materials used as coating material

are summarized in *Table 2*. Commercial paraffin wax is used as control. *Table 3* summarizes the characteristics of the coated surface of palm-based lipids/waxes.

TABLE 2. SOME PROPERTIES OF THE LIPID/WAX MATERIALS

Lipid	Reported Purity	Slip Melting Point (°C)	Iodine Value (Wijs)	Saponification Value mg KOH/g (max)
Mixture of C ₁₆ - C ₁₈ Alcohols	Commercial	56.2	0.31	0
Palmitic Acid	98%	55.0	0.38	208
RBD Palm Stearin	Commercial	53.7	26.2	191
Hydrogenated Palm Olein	Commercial	41.7	29.0	189
Paraffin	Commercial	59.6	0	0

TABLE 3. CHARACTERISTICS OF THE LIPID/WAX COATED SURFACE

Lipid/Wax	Characteristics of the Surface
Palm oil-based 1	Smooth surface, not brittle, flexible, transparent, glossy, non-tacky, tasteless and odourless.
Palm oil-based 2	Rough surface, brittle, hard, white, glossy, non-tacky, tasteless and odourless.
Palm oil-based 3	Smooth and oily surface, slightly brittle, transparent (yellowish), glossy, non-tacky, oily taste and oily odour.
Palm oil-based 4	Smooth and very oily surface, brittle, soft, transparent (yellowish), less glossy, non-tacky, oily taste and oily odour.
Paraffin wax	Smooth surface, not brittle, flexible, transparent, glossy, non-tacky, tasteless and odourless.

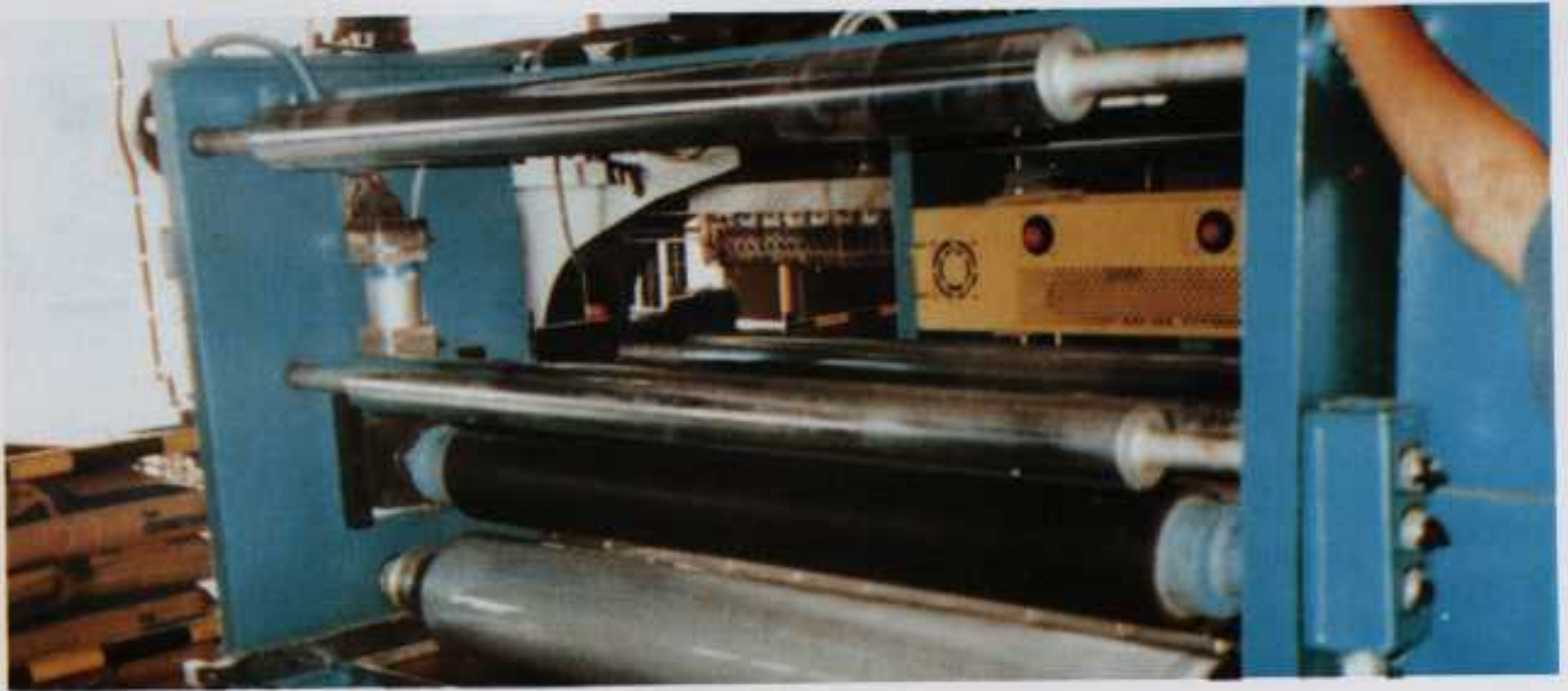


Figure 1. Gravure coating method was used during the pre-commercial trial.

It can be seen that the characteristics of the coated surface of some palm-based coating materials are quite similar to that of paraffin wax film. There may be possibilities to replace paraffin wax film with palm-based materials for coating of paper used in food wrapping. The advantage of paraffin wax is that it is relatively inexpensive compared to palm-based materials. However, palm-based materials offer several major advantages such as edible, biodegradable and renewable.

Coating with lipids/waxes as compared to polyethylene laminating processing has the advantage that a lower melting temperature of the material is required. As a result this can reduce the operational cost.

The characteristics and properties of lipid films can either be improved with hot melt formulation or improving the operational coating machine including the coating conditions. Pre-commercial trials in local factory using simple gravure roller coater have been successfully conducted. Palm-based materials can be coated on the paper by melting the materials at $65^{\circ}\text{C} - 70^{\circ}\text{C}$ and running the machine at a high speed $100 - 200 \text{ m/min}$. The high

speed coating and low temperatures are required to avoid penetration effect.

Figure 1 shows a schematic diagram of gravure coating method which is used during the pre-commercial trial.

Palm-based materials/wax coated paper was found to have better water resistance. There was penetration after one day. However, palm-based materials/wax coated papers have poor oil resistance. The study found that oil penetration occurred after $15 - 20$ minutes. This problem has been tackled by adding some of the food grade additives. The result showed that, by adding 1% of the additives, first appearance of oil penetration occurred after $12 - 13$ hours.

Surface parameters of coated paper such as rubproofness resistance, abrasion resistance, folding endurance, heat-seal properties, etc. have to be improved to vary or widen the usage of the coated paper in food packaging industry.

Since most of the palm-based coating materials have low melting point which is $< 70^{\circ}\text{C}$, food wrappers produced are not suitable to wrap at higher temperature or

hot food. It will be more interesting to us if higher melting point palm-based waxes can be synthesised which will have very broad applications in food wrapping. As for the time being, palm-based coating paper has the potential to be used as bread wrappers; fish, meat or vegetable wrappers; drinking cups; frozen food and paper milk cartons.

CONCLUSION

- * Some of palm-based materials have the potential to replace paraffin wax for food wrapping.
- * Palm-based materials offer several advantages compared to paraffin wax or polyethylene coated/laminated paper, such as edible, renewable resources and biodegradable.
- * Palm-based coating papers have the potential to be used as bread, fish, meat or vegetable wrappers; drinking cups; frozen food and paper milk cartons.

ACKNOWLEDGEMENT

The authors wish to thank the Director-General of PORIM for his permission to publish this paper. ■

REFERENCES

- CASEY, J P (1980). *Pulp and Paper, Chemistry and Chemical Technology*, 3rd. Ed., Vol. IV, p. 2541.
- CA 90: 24270x. Murakami, Takashi; Cosimo, Mastaba; Matsutami, Nabiac; Tukai, Macchiato and Aeneid, Koshi. Japan Kokai Tokyo Koho 78, 108, 084 (CI. C091C3/18), 20 Sept., 1978.
- CA 87: 186212v. Causin, Charles and Cavroy, Patrick. *Fatty Materials for Coating Paper and Paperboard*. Brax Pedido PI. 7504, 423 (CI. C11 B11/10), 15 Feb. 1977.
- CA 118: 58479. Mettler, Michael. Ger. DE 4, 133, 716 (CI. D21 H19/44), 3 Dec., 1992.
- CA 119: 205540y. Hajek, Karel; Lunak, Stranisloy; Bandzuch, Jan; Kitzler, Toroslav and Kasha, Jiri. Milan, Czech. C5 273, 224 (CI. C08 G063/10), 19 Feb., 1992, Appl. 89/4, 811, 15 Aug., 1989.
- The Selected Industry Studies*, 1993 Edition, pp. 51 - 64.