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Use of waxes and rubbers to create SUPD-compliant coated packaging

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The Single-Use Plastics Directive, or SUPD came into force on 3 July 2021 in the European Union in 2021. The main goal of the SUPD is to reduce the amount of plastic waste in the environment, especially the marine environment. SUPD restricts material choice in cotton bud sticks, cutlery, plates, straws, stirrers, sticks for balloons, cups, food and beverage containers. Synthetic polymers and oxo-degradable plastics are forbidden. This work was performed to create and assess SUPD-compliant natural options available to replace these plastics. Waxes and rubbers are some of the most common naturally available materials which impart water vapor and oxygen barrier properties. Different waxes - rice bran, carnauba, rapeseed, beeswax and rubbers - caoutchouc, guayule and chicle - and their combinations were tested in different ratios. They were coated on paperboard using different techniques like dispersion coating, hot melting coating in single and multilayer forms and their barrier properties were measured. The key target of this research was to identify the best options which can provide barrier properties, heat sealability and good printability. Out of the various options tested, rice bran wax provided a good moisture barrier whereas rubber helped in providing heat-sealability and a printable surface. A water vapor transmission rate (WVTR) in the range of 3-5 gm/m2/24 hr at 23 °C and 50% relative humidity was achieved with a multilayer product.

Keywords: barrier paper; multilayer structure; wax coating; rubber coating; water vapor barrier; oxygen barrier; cold sealing; coat weight

1 Introduction

Single-use plastic directive (SUPD) is legislation which aims to reduce the impact of plastic products on environment especially in the marine environment.[1] These include plastic straws, plastic cutlery, cotton swabs, balloon sticks, food, beverage containers made from expanded polystyrene and many more. The directive was passed on June 2019 and came into force on 3rd July 2021. Plastics are widely used in varied applications in food packaging. Due to their tendency to not biodegrade and poor recyclability, this has led to land and marine pollution.[2]

SUPD sets limits on the alternatives which can be used as a replacement for the banned products. Either a monomeric or naturally polymerized items can be used to create an alternatives. There are several natural polymers available but very few of them provide the required properties for the end use applications like strength, barrier, and optical properties. Natural waxes are non-polymeric mixtures of organic compounds mainly esters of fatty acids and fatty alcohols. They have been widely used in different applications like food, packaging, cosmetics, polishes etc.[3] However, utilization of waxes in packaging industry as a standalone product is very limited. The low melting point and lacking water vapor barrier properties have limited the use of waxes in packaging application. We have studied here the potential of the natural waxes and rubbers in packaging application specially with respect to water vapor transmission rate (WVTR) barrier properties. Natural waxes are widely available and can be potentially used in creating alternatives for plastic coated products.

2 Methods

In this study we have studied different waxes and rubbers from varied sources and assessed their barrier properties with respect to creating a moisture barrier. Commercial waxes, both in solid and

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dispersion forms, were coated on a paper substrate. Beeswax, carnauba wax, anionic and cationic rapeseed wax, rice bran wax and four mixed wax products of proprietary composition (100, 200, RD22A and RD22B) were used. Two different coating methods were used in this study: dispersion coating and hot melt coating.

Dispersion coatings were done on 210 g/m2 paper board using an Erichsen coater (model no. 509/15). The commercial wax dispersion was coated on a paperboard substrate (Metsä Board Prime FBB Bright) at different grammages using a spiral drawdown rod (10-60 µm). The paperboards were then dried in oven at 120 °C for 5 mins for further analysis.

Hot melt coatings were done on the same paperboard using a spiral draw down rod (10-30 µm) in the heated environment of an oven. The temperature of the oven was kept at 120 °C. The paper was clamped to a metal plate and kept in the oven for heating at 120 °C along with the draw down rod. All the equipment was heated for 5 minutes in the oven. The melted wax was poured on the paper sheets and metered using draw down rod. The coated sheet was then brought at room temperature and allowed to cool down to create a coating layer on the paper.

Nanocellulose was made by enzymatic treatment followed by two passes of fluidization with Microfluidics Microfluidizer Processor M-110EH. Nanocellulose coating was done with Erichsen coater using a draw down rod (200 µm).

After the coating process, the coated paper samples were conditioned for 24 h at 23 °C and 50% RH. After conditioning, coating grammage, paper thickness and WVTR was measured. Water vapor transmission rate was measured using a Mocon device (MOCON PERMATRAN-W 3/34) at 23 °C and 50% RH.

3 Results and Discussion

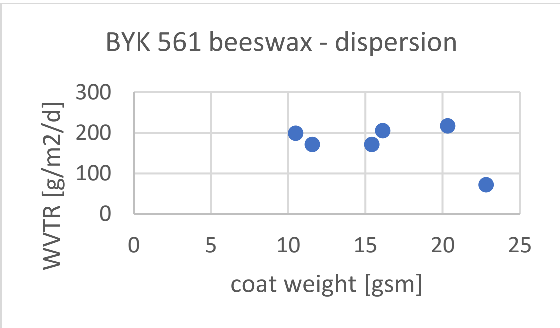

Figure 1 Bees wax

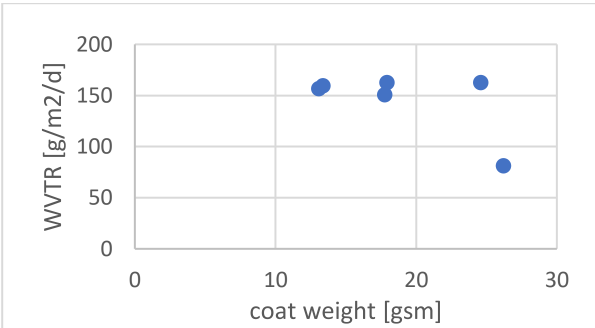

Figure 2 Carnauba wax

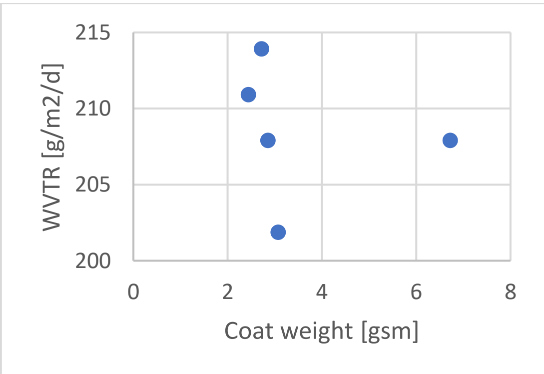

Figure 3 Rapeseed wax anionic emulsion

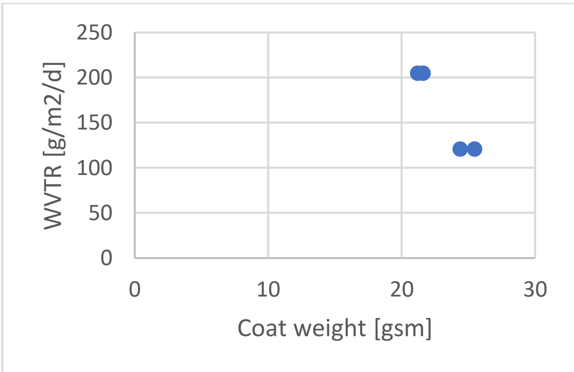

Figure 4 Rapeseed wax cationic emulsion

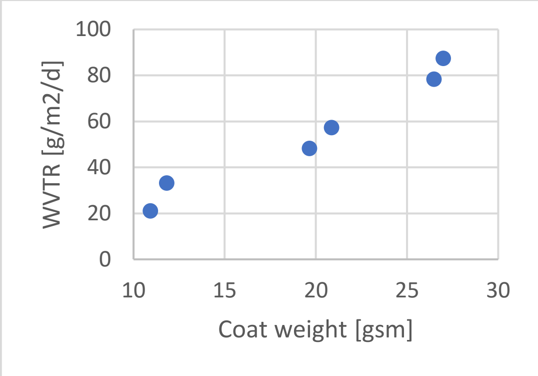

Figure 5 Proprietary wax 100

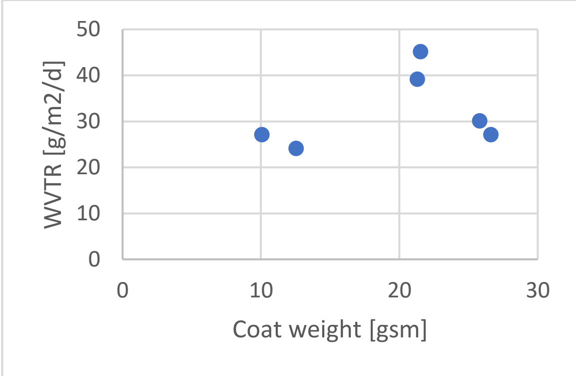

Figure 6 Proprietary wax 200

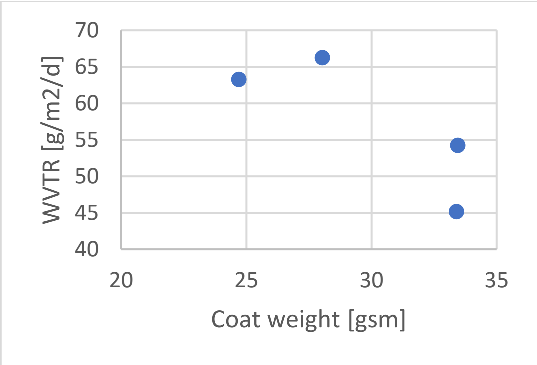

Figure 7 Proprietary wax RD22A

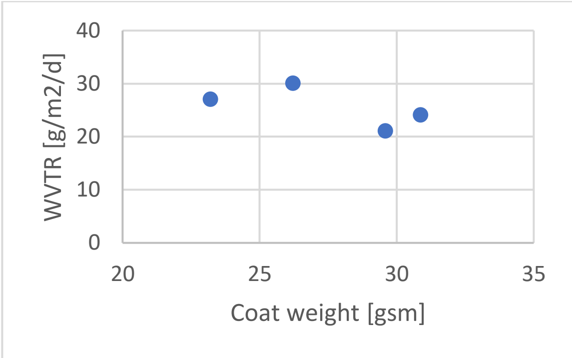

Figure 8 Proprietary wax RD22b

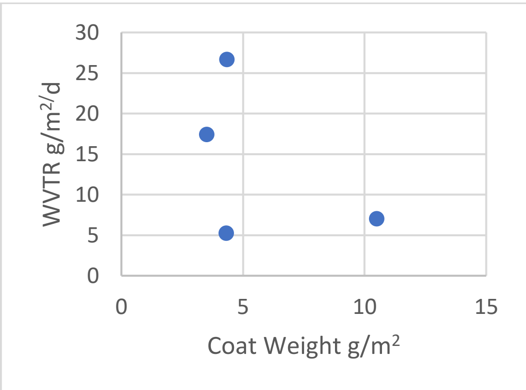

Figure 9 Rice bran wax

Beeswax, carnauba, rapeseed, rice bran and proprietary waxes coating showed different barrier water vapor barrier properties (Figure 1-8). Amongst all the waxes coated, the best properties were delivered by rice bran wax (Figure 9), followed by proprietary wax 100 and 200 (Figure 5 and Figure 6). Rice bran wax gave the best WVTR of 5 g/m2/d at a lowest coat weight of 5 g/m2, whereas proprietary wax 100 provided a good WVTR in the range of 20.25 g/m2/d. Beeswax (Figure 1), carnauba (Figure 2), rapeseed (Figure 3, Figure 4) and RD22A & RD22B (Figure 7 and Figure 8) provide a mediocre WVTR ranging between 60-220 g/m2/d. There was no obvious correlation in coat weight and water vapor barrier in general. This might be due to the low melting point of waxes which creates a sensitive coated surface which is prone to any surface damage. The coating was deformed with the slightest touch with proprietary waxes 100, 200, RD22A and RD22B.

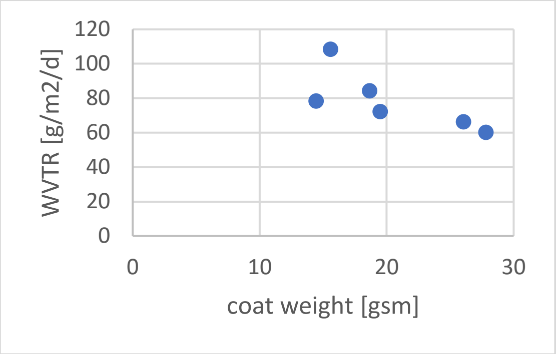

Figure 10 Rubber + wax (50:50)

Wax coated paper cannot be printed. Unvulcanized natural rubber is hydrophobic and sticky, which can enhance the surface properties when mixed with waxes. Proprietary wax 100 provided a good water vapor barrier and so it was selected to be mixed with rubber emulsion to see the impact on the barrier and printing properties. The wax and rubber were mixed in 50:50 ratio and coated on paper. The barrier measurements showed that with the addition of rubber emulsion, the water vapor barrier performance was reduced from 21 g/m2/day to 60 g/m2/d (Figure 10). Though the barrier properties achieved were mediocre, added rubber enhanced the surface properties and provided a printable surface along with a cold sealing property. Natural rubber (caoutchouc from *Hevea brasiliensis*) contains allergenic proteins, which render them unsuitable for the food and beverage packaging application.[4] However, these can be removed with a purification process such as the Vytex technology.[5] The rubber emulsion used in our experiments has been certified as non-allergenic and thus could be used in packaging applications for food and beverages.

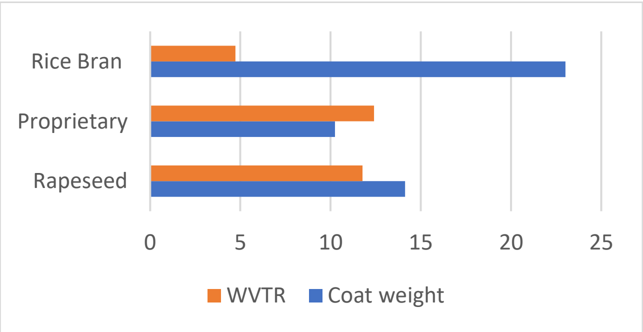

Figure 11 Comparison of the best hot melt coating results for each wax

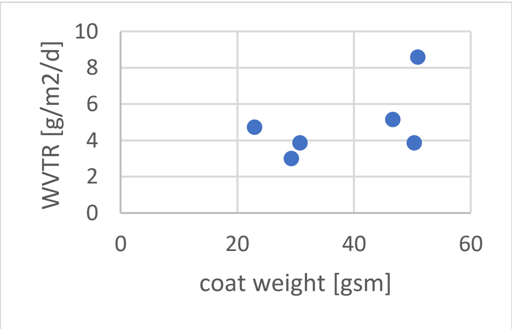

Figure 12 Water vapor transmission vs. coat weight for hot melt-coated rice bran wax

Hot melt coating provided comparatively better results when compared to their respective dispersions (Figure 11). At higher coat weights, the water vapor barrier performance can be seen deteriorating (Figure 12). This is due to the brittleness of film which has a higher to tendency to crack when the coat weight increases. This leads to creation of paths for gases to penetrate, which reduces the barrier performance of film. Rice bran wax provides good water vapor barrier both in dispersion as well as hot melt coating at same coat weight.

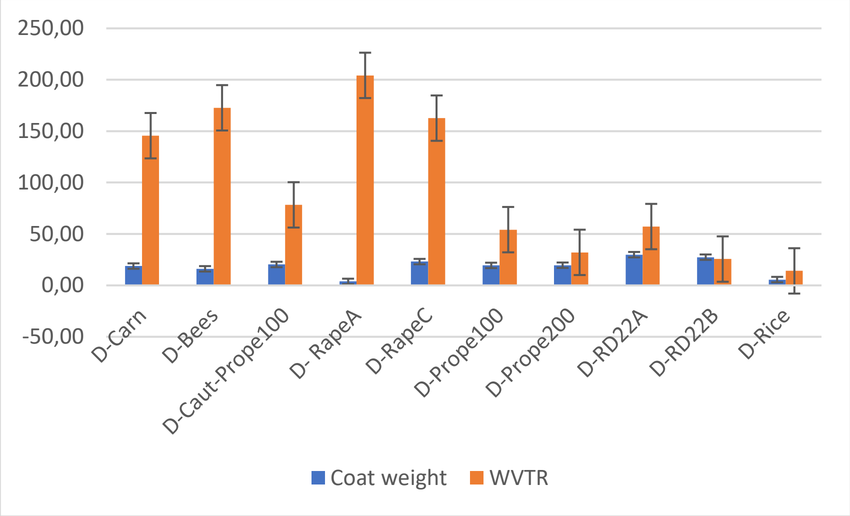

Figure 13 Comparison of different waxes as dispersion coatings

Different waxes provided different water vapor barrier properties at varied coat weight. The best performance was achieved from rice bran wax both in dispersion and hot melt coating of 5 g/m2/d at 5 g/m2 coat weight and 4.73 g/m2/day at 23 g/m2 (Figure 13), respectively. In general, the hot melt coatings provide better barrier properties in comparison to dispersion coating. It is difficult to achieve low coat weight by hot melt application, and at high coat weights the films tend to crack which makes it a challenging option. Dispersion coating is preferred for barrier application as it can provide a comparatively a lower coat weight and the film coated is less brittle compared to hot melt coatings.

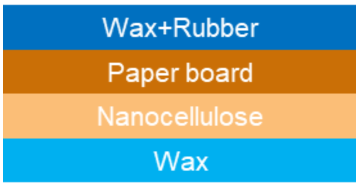

Figure 14 Multilayer structure

A multilayer structure was created to provide an overall moisture and oxygen barrier properties (Figure 14). It also had a printable top surface with a sealing strength. The top side of the paperboard was coated with a mixture of wax and rubber dispersion (50:50) which provides it a moisture barrier, a printable surface and sealing properties. The bottom layer of the paperboard was coated with nanocellulose to provide an oxygen barrier. Since nanocellulose is sensitive to moisture, it can be deteriorated by water, which reduces its oxygen barrier properties. Therefore, the nanocellulose was coated with wax as a protective layer for the moisture penetration.

4 Conclusion

Rice bran wax provides an excellent performance in providing a good water vapor barrier when compared to other natural waxes tested. It provides a good WVTR both in dispersion and hot melt coating in the range of 5 g/m2/day and 4.31 g/m2/day at coat weights of 5 and 23 g/m2, respectively. Generally, hot melt coatings provide a better water vapor barrier compared to dispersion coatings but achieving a lower coat weight is a challenge with hot melt coating. Higher coat weights do not improve the barrier properties in hot melt coatings. This is due to the brittleness of the film, which at high coat weight has a tendency to crack and create paths for gases to penetrate. Based on the properties achieved from rice bran wax, it could potentially replace plastic coating in cold food and beverage packaging solutions. The rubber and wax coating could also be used in packaging dry food as it provides good barrier, sealing and printing properties.

References

1. European Union. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. European Union. 2019.
2. Ritchie H, Roser M. Plastic pollution. https://ourworldindata.org/plastic-pollution
3. Krendlinger EJ, Wolfmeier UH. *Natural and Synthetic Waxes: Origin, Production, Technology, and Applications*. John Wiley & Sons; 2022.
4. Wagner S, Breiteneder H. Hevea brasiliensis latex allergens: current panel and clinical relevance. *International archives of allergy and immunology*. 2005;136(1):90-97.
5. Swansona M. Vytex® Natural Rubber Latex: An Eco-Friendly Alternative Raw Material.