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Improvement of physical-mechanical and optical properties of the packaging production through coating with aqueous polymer dispersions in accordance with the environmental protection requirements

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The nowadays growing demands toward sustainable development and environmental protection led to increased interest in bio-degradable materials from renewable sources. Aqueous polymer dispersions are used for surface coating of paper and cardboard in the packaging industry in order to improve the physical-mechanical and optical properties of the production. This article summarizes the main parameters in the preparation, processing and utilization of aqueous dispersions based on synthetic and bio-degradable polymers for coatings in packaging paperboard production. It shows that the bio-sourced aqueous coating have acceptable physical-mechanical properties, but lower gloss than the conventional water based coatings.

Key words: bio-degradable polymers, renewable resources, packaging, coating

INTRODUCTION

The aqueous coatings (also called dispersion coatings) are water-based coatings that are used for protection of the printed material from abrasion, scratches, and finger prints. They provide fast further processing and enhance the optical and physical-mechanical properties of the printing production. The dispersion coatings attract attention to the end-product with gloss, matt, gold, silver and even smell effects and add some valuable functions – barrier, anti-migration, anti-slippery, anti-bacterial etc. [2]

Water-based coatings dry physically by means of the absorption of the coating into the substrate and the evaporation of water (Figure 1). This drying is achieved through hot air and infrared. With the drying, water is extracted from the coating. The polymer particles approach each other and form the coating film. Water-based coatings, as a result of their many advantages, have become the leading technology in the printing industry: environmentally friendly, odorless, tasteless, no yellowing and reduction of spray powder. [1]

Water-based coatings contents 25-35% solids, 60-70% water and 5% additives. Their main ingredients are:

- Dispersions of acrylate and styrene acrylate polymers
- Alkaline-neutralized resins dissolved in water
- Wax dispersions (polyethylene waxes) or/and silicones for scuff and rub resistance
- Film-forming agents
- Additives to enhance certain properties

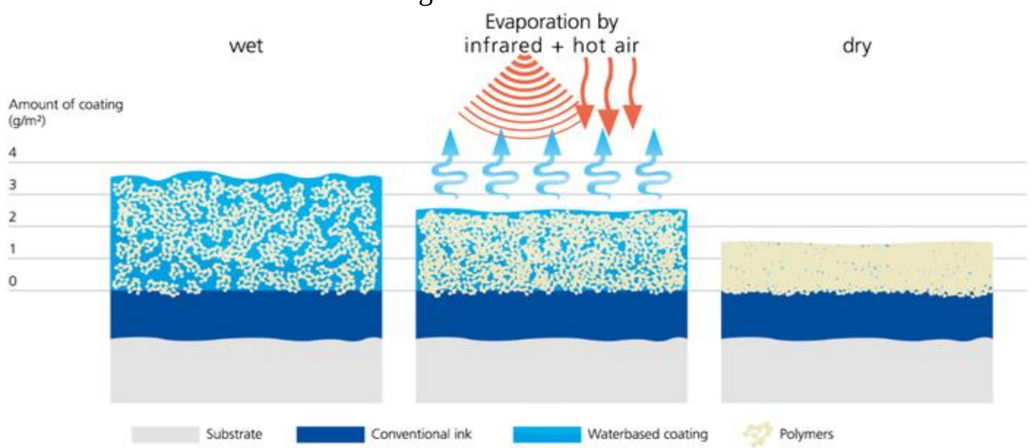

Figure 1. Drying method of water-based coatings [2].

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Polymer dispersions

Polymer dispersions are stabilized water-borne emulsion polymers with colloidal particles in water. Many polymers are not amendable to emulsion polymerization. In such cases the dispersion must be prepared by dispersing the water insoluble performed polymer into an aqueous phase. These “pseudo dispersions” contain often emulsifying agent, which prevents or slows down agglomeration settling. Polymer dispersions are formulated into coatings with fillers, waxes and additives. All the additives are used to improve barrier properties, runability, decrease blocking and ensure easy post-processing.

As the polymer morphology affects the film formation, the goal is to keep polymer particles amorphous in dispersions. The methods for preparing pseudo dispersions can be divided into two groups: VOC based and thermo/mechanical. [3]

Biopolymers and bio-coatings

In recent years an increasing interest is observed in development of eco-friendly materials. Oil-based polymers are slowly being replaced by such from renewable resources. Biodegradability and compostability are playing very important role for environmental sustainability. Some biodegradable polymers possess excellent mechanical properties, thermal and UV resistance, however production capacity, processing challenges, adhesion, barrier properties and the price are not yet on a sufficient level for the demands of the packaging and printing industries. Biopolymer dispersions find use in various applications, such as adhesives, inks, coatings, etc. From the Biopolymers family only few cover the performance requirements for applying on printing products. [2]

According to European directives and EN 13432 standard, the key requirements for biodegradable products are:

- Chemical composition: the standard sets limits for volatile matter, heavy metals (Cu, Zn, Ni, Cd, Pb, Hg, Cr, Mo, Se, As) and fluorine

Biodegradation: chemical breakdown of materials into CO2, water and minerals. Pursuant to the standard at least 90% of the materials have to be broken down by biological action within 6 months.

Table 1. Composition in traditional water-based coatings vs coatings based on renewable resources

Traditional waterbased coatings	Coatings based on renewable resources
Acrylate / styrol acrylate dispersions	Natural resins
Polyethylene waxes	Natural waxes
Wetting agents and additives	Wetting agents and additives
Water	Water

- Disintegration: the physical decomposition of a product into tiny pieces. After 12 weeks at least 90% of the product should be able to pass through a 2x2 mm. mesh
- Quality of the final compost and ecotoxicity: the quality of the compost should not decline as a result of the added material. [4]

The goal of this study is to compare 2 types of water-based coatings, their properties and characteristics applied with different screen rollers – the reference coating, based on synthetic polymer – and the tested coating, based on biopolymer.

EXPERIMENTAL

Materials

Table 1 shows the comparison in composition between conventional water-based coating and coatings based on renewable resources. As a reference has been used conventional acrylic water-based multipurpose, gloss coating with fast drying speed and high wet block resistance – ACTEGA Terra Wet GlossG9/535 (45 sec viscosity). The tested coating was water-based gloss coating, based on renewable resources - ACTEGA Terra Green Gloss G5/200 (45 sec viscosity).

Table 2. Physical properties of the materials used.

Physical Properties:	ACTEGA Terra Wet Gloss G9/535 (45 sec)	ACTEGA Terra Green Gloss G5/200 (45 sec)
Boiling temperature / boiling range	(1013 hPa) > 100 °C	(1013 hPa) > 100 °C
Density :	20 °C - 1,04 g/cm	20 °C - 1,04 g/cm
pH value :	7 - 9,5	7 - 9,5
Solid content:	25 – 45 Wt %	25 – 45 Wt %
Max.VOCcon (EC):	2,322 Wt%	0,278 Wt %

Table 3. Composition and characterization of the materials used.

Ingredients:	ACTEGA Terra Wet GlossG9/535 (45 sec)	ACTEGA Terra Green Gloss G5/200 (45 sec)
Styrene Acrylic Resin and/or Emulsion	40- 50%	30-50% (renewable resins)
Polyethylene/wax	1-10%	1-10%
Silicon Defoamer	0-1%	0-1%
Wetting agent/sulfosuccinate	5-10%	1-5%
Water	20-40%	40-50%
Propylene glycol	1-5%	-

Characteristics of the materials

Resins and waxes used for Terra Green are amply available and are extracted from the sources that are not competing with the food chain. No plants, trees or animals are eliminated for the waxes and resins used in TerraGreen. Comparable to caoutchouc, the used materials are harvested and the biomass remains existing. The resins and waxes used grow naturally in the wild or they are harvested at traditionally existing and sustainably cultivated plantations in Europe, South America and Asia. TerraGreen has no negative impact on existing eco systems and is certified to EN 13432. [1]

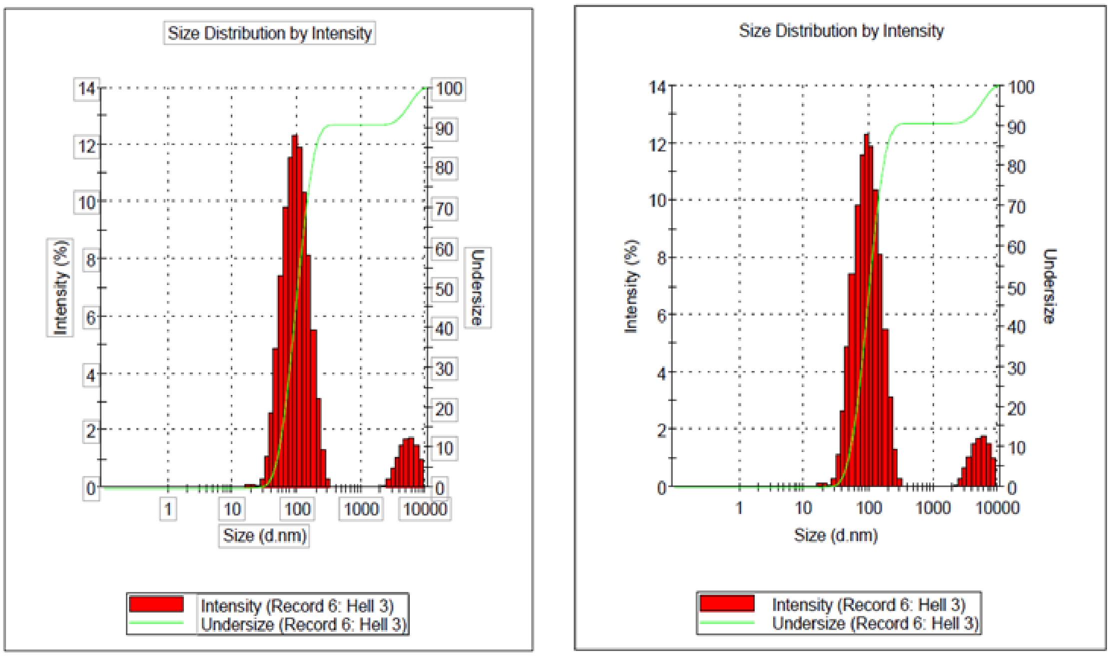

Figure 2. Comparison of particles size distributions as a function of intensity.

Table 2 and Table 3 show the properties and characteristic contents of both coatings. From table 2 we can obtain information about the physical properties of both coatings. The only difference is in Volatile Organic Compounds content, which is much lower in the BIO-Coating. Table 3 shows the detailed information about the ingredients in both coating types. The water content in the BIO-

Coating exceeds the water content in the acrylic one by max. 10%, which could influence the drying and runability. Figure 2 shows the size distribution report with identical peak intensities in both coatings.

Methods

Both coatings were applied on offset printing press HEIDELBERG CD74 4+L, under same conditions and initial parameters:

- Material – Cardboard – LWC 170 g/m^2
- Ceramic Anilox rollers:
- Zecher, 160L/cm, 60 °, 7,5 cm^3/m^2 – Wet application – 2,5 g/m^2
- Zecher, 100L/cm, 60 °, 13 cm^3/m^2 - Wet application – 3,8 g/m^2
- Zecher, 80L/cm, 60 °, 15 cm^3/m^2 - Wet application – 5,0 g/m^2
- Zecher, 60L/cm, 60 °, 17 cm^3/m^2 - Wet application – 6,0 g/m^2
- The wet application amount of varnish is about 1/3 to 1/4 of the theoretical cell volume of the screen roller.
- IR Lamps power – 15 %, hot air – 100 %
- Temperature in stack – 35° C
- Equal press speed – 8 000 sheets/hour

RESULTS AND DISCUSSIONS

Gloss after coating

Figure 3 shows the gloss changes after application of the coatings with the different anilox rollers. The BIO-coating shows lower gloss in comparison to the conventional one with an 8-10 gloss units (GU) in all applied quantities.

Adhesion test

A 5 c. piece of tape TESA Film, 57341 Beiersdorf was applied on the top of the coated materials. The tape was removed by hand from the printed surface. The adhesion of the coating was determined by the amount of coating that was removed when the tape is peeled off. The results are summarized in Table 4.

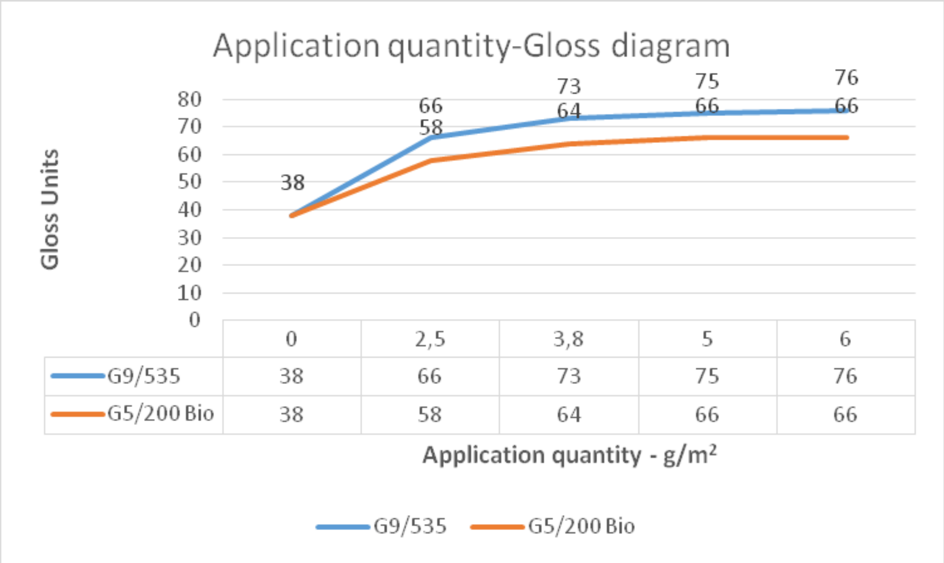

Figure 3. Application quantity-Gloss diagram.

Table 4. Adhesion test results.

Coating	2,5 g/m^2	3,8 g/m^2	5 g/m^2	6 g/m^2
G9/535	Average	Good	Good	Good
G5/200 - BIO	Average	Good	Good	Good

There was no performance difference between both coatings on the adhesion test, which indicates good adhesion of the BIO-Coating.

Scratch resistance

- Industry standard for most application is the scratch test - if the coating/ink is not removed by your fingernail, it is considered to exhibit acceptable adhesion and scratch resistance. If the surface is damaged, it indicates inadequate curing or an excessively soft ink/coating film.

All samples showed good scratch resistance. There was no difference between reference and tested coatings on the scratch resistance test.

I. Rub resistance - Rub resistance describes the ability of printed paperboard to withstand marking, scuffing or smudging during handling in conversion, packaging, distribution and use. Poor rub resistance is apparent if, after normal handling and use, the printed or varnished paperboard surface is marked, scuffed or smudged. An extremely demanding environment or special end use may require extra protection against rubbing. This protection might be provided by such treatments as extrusion coating or lamination. Laboratory rub testing of dry print can be done using an optional number of rubs and pressure. The results are assessed visually against standards. A block is either moved back and forth over an area of printed sample or moved by rotary motion in an orbital path over the print depending on the instrument used. A record is made of the number of rubs e.g. 50 or 100 and rub pressure 20 N. The degree of surface rub is subjectively compared to reference standards. 4 tests were performed – 50, 100, 200, 500 rubs. All samples showed very good rub resistance with no difference between the reference and tested coatings.

CONCLUSIONS

As a result from the tests, it can be concluded, that the biodegradable coating can comply with the main physical-mechanical characteristics required from a water-based coating. However, the bio-based aqueous coating showed lower gloss compared to the conventional water-based coating. The next step in this direction is the improvement of the optical characteristics which would clearly show the increase in the gloss.

REFFERENCES

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ПОДОБРЯВАНЕ НА ФИЗИКО-МЕХАНИЧНИТЕ И ОПТИЧНИТЕ СВОЙСТВА НА ОПАКОВКИТЕ ЧРЕЗ ПОКРИТИЕ С ВОДНИ ПОЛИМЕРНИ ДИСПЕРСИИ В СЪОТВЕТСТВИЕ С ИЗИСКВАНИЯТА ЗА ОПАЗВАНЕ НА ОКОЛНАТА СРЕДА

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(Резюме)

Нарастващите изисквания към устойчиво развитие и опазване на околната среда в наши дни доведоха до засилен интерес към биоразградими материали от възобновяеми източници. Водните полимерни дисперсии се използват за повърхностно облагородяване на хартия и картон в опаковъчната индустрия, като целта е да се подобрят физико-механичните и оптичните свойства на печатната продукция. Тази статия обобщава основните параметри при приготвянето, обработката и използването на водни дисперсии на базата на синтетични и биоразградими полимери за покрития в производството на картонени опаковки. Изследването показва, че биоразградимите вододисперсионни лакове имат приемливи физико-механични свойства, но по-нисък блясък от конвенционалните вододисперсионни лакове.