Renewable Gas Barriers for Paper Coating

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ABSTRACT

We annually produce 400 million tonnes of paper and board globally and a large part is produced in the Nordic countries. Almost all paper is coated and there is specifically a need for renewable gas barriers for packaging use. Dispersion coating is an efficient coating process, but also one with high demands on the rheological properties of the coating formulation. Dispersion coating based on cereal proteins was developed and the coatings were both strong and gas tight.

INTRODUCTION

A wide range of paper and paperboard is currently used in packaging, from lightweight tissues for tea bags to heavy duty cardboard boxes. It is the most common materials in consumer packaging. Of all paper and paperboard 10% is used for packaging and over half of this is used by the food industry. Almost all paper and board is coated for surface smoothness, printability, gloss or for barrier functionnality.

Coating of paper for barrier purposes can be achieved by extrusion coating from a melt or by dispersion coating. Extrusion is widely used in packaging application such as liquid board where multiple polymer layers give the specific barrier functionality for e.g. gases, liquids, aroma and food protection. In dispersion coating a viscoelastic dispersion is distributed to cover the surface and then dried to form a solid coating. Extrusion coating is versatile whereas dispersion coating is fast and can be applied directly in the paper making process and thus is a cost-effective coating alternative.

Paper and paperboard are renewable materials whereas coatings generally are produced from petroleum based resources, or even metal when it comes to gas barriers (thin aluminium foil is common). In order to supply renewable gas barriers, dispersion coatings based on cereal proteins has been developed in a Swedish project, "Renewable Functional Barriers", involving major academic and institute partners together with paper and pulp industry as well as the food industry. Dispersion coating is a high-speed process where the paper speed is up to 1000-2000 m/min and the shear rates during dispersion coating reach 10^6 s^{-1}. The rheology of the dispersion is therefore crucial.

The aim of the present study was to formulate dispersions based on renewable components, and to produce coatings with good gas barrier. Dispersions of the maize protein zein were developed and coated on paper and paper board. The coating was performed both at laboratory conditions and at pilot scale and resulted in coatings with oxygen permeability close to that of commonly used petroleum based polymers.

MATERIALS AND METHODS

The paper used in the coating trials was greaseproof paper (Nordic Paper, Säffle, Sweden) with a grammage of 50 g/m^2, and zein and polyethylene glycol (PEG) was obtained from Sigma-Aldrich (Stockholm, Sweden) as well as from large scale production. Nano-clay Barrisurf LX was obtained from Imerys Mineral AB (Mölnlycke, Sweden).

Zein was dissolved in 80% (w/w) aqueous ethanol at 70°C and the solution was allowed to cool. The solution was then slowly poured into an equal amount of cold (11°C) water. The dispersion produced was then stirred in an open beaker over night to allow the ethanol to evaporate. Zein was also dissolved in aqueous solution at high pH. PEG was then added (30% PEG/zein), as well as the nano-clay. Different formulations with a dry solid content of 19-39% (w/w) were developed and applied on paper using K hand coater (Largo AB, Göteborg, Sweden).

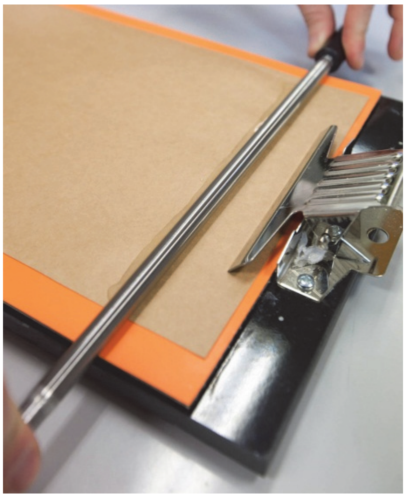

Figure 1. Lab-scale coating of paper.

The viscosity of the coating solutions were determined using an ARES G2 (TA Instruments, New Castle, USA) and a Stresstech HR Rheometer (Rheologica Instruments, Lund, Sweden) equipped with concentric cylinder geometry.

Oxygen transmission rate was measured using an OX-Tran 2/20 (MOCON, Minneapolis, MN, USA) according to ASTM D3985. Water vapor transmission was measured according to the standard ASTM E96-90.

RESULTS AND DISCUSSION

Figure 2 shows the flow curves for different formulations. The different formulations can be grouped into three different groups according to the level of the viscosity. The viscosity mainly depended on the dry solid content, but also on the specific coating formulation. The formulation with 26% dry solid content shows an irregular flow curve depending on aggregation of the protein. This was also reflected by the relative influence of different formulation parameters on the viscosity, where for the water solutions the pH had the strongest influence, even stronger than the total dry solid content.

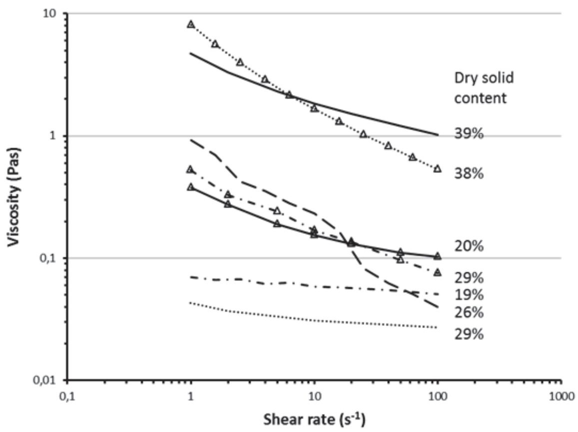

Figure 2. Viscosity of different coating formulations.

The coating formulations were coated on paper and produced strong coatings with low oxygen and water vapour permeability.

ACKNOWLEDGMENTS

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