Studies on synthetic polymers as paper coating matrials

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SUMMARY

Coatingsbased on methyl acrylate, butyl acrylate and polyurethanes were prepared and applied to kraft paper. These coatings were found to improve the burst factor by 50% and reduce the air permeability by 75% but the folding strength was reduced in all cases except the polyurethane coated papers.

Natural polymers such as starch, glue, gelatine and casein have been traditionally used to bind the pigments and other ingredients of the furnish and to impart a smooth finish to the paper web to make it receptive to writing and printing[1]. With the advancement of printing methods and materials and severe coditions of use for packaging papers more exacting demands were made on the paper coatings. Synthetic polymers have provided solution to many of such problems, polyvinyls, styrene, butadiene, phenolics, amino resins, acrylics and polyurethanes are some of these polymer resins[2]. The work in this field is mostly covered by patent literature or proprietary formulations developed by individual manufacturers. There is very little information on effect produced by easily obtainable individual pure lattices which may be formulated to desired requirement[3-5].

This work reports the effect of a few typical coatings based on polyacrylates and polyurethanes which were made in the laboratory on the physical properties of a kraft based paper on their application as surface coatings.

Result and Discussion

The characteristics of the polymer emulsions and solutions used as coatings have been given in Table 1. The acrylic coatings were based on methyl and butyl acrylates. Butyl acrylate of two types having different average molecular weight (B and BH) were used. The solids content of the coatings were from 25-35% and viscosity varied from 0.2 to 0.4 Ns/m^2. The molecular weight range was from 8-160 $\times 10^3$ except for the high molecular weight butyl acrylate (510 $\times 10^3$). This high value seems to have adversely affected the stability of emulsion which was found lowest for this class The low stability value of 15 days for polyurethanes is however, very satisfactory because these resins are known to polymerise further any cross link in presence of atmospheric moisture and thus gel during storage. This coating comes in a separate category as it is used from a solvent base and not aqueous emulsions, as in the case of acrylates. The properties of coating listed in Table 1 are for recipes which have been chosen out of several alternatives available from the work on these poly-

TABLE—1
CHARACTERISTICS OF COATINGS

S.N.	Polymer → Symbol →	Methyl Acrylate A	Butyl Acrylate B	Butyl Acrylate BH	Poly urethane U
1	Total solids %	28	25	30	35
2	Viscosity, Ns/m^2	0.21	0.23	0.38	0.40
3	Molecular weight x 10^{-4}	1.1	16	51	0.80
4	Stability (days)	>90	>90	70	15

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mers and it is not suprising that these represent a very good combination of properties for coatings suitable for external application by coaters based on roll, air knife or brush[6-8].

The effect of these cotings on the properties of base kraft papers can be examined from Table 2.

The thickness of the coatings varies from 5 to 10 g/m² (4—8 μm) for single coating and 10 to 20 g/m² for coatings on two sides. Almost all coatings have improved the burst strength of paper varying from 25% to almost 100% for polyurethane coated papers. A similar effect was noticed on the burst factor which annuls the effect of variation is thickness of sheets. The range of improvement in this case was however, from 5% for high molecular weight butyl acrylate (BH) to 60% for double coated methyl acrylate paper.

Almost all coatings have decreased the folding Strength of paper except polyurethane which has resulted in hundred percent rise. This is probably due to stiffening of base paper by acrylic resins where as polyurethanes form a film which is elastic and independently strong and thus adds to folding endurance.

The property of foremost significance for packaging, to meet certain functional requirements is air permeability, which reflects the permeability of gases in general or the porosity of the paper.

Butyl acrylate has shown outstanding improvement in reducing the permeabilily by as much as 99.5% though other resins have also reduced it by about 50-70%.

Comparing the various acrylates it appears that high molecular weight butyl acrylate does not give advantage in reducing permeability and a low molecular weight resin with narrow size distribution gives the best overall results. Methyl acrylate is found satisfactory to improve these properties, and a coating on one side is sufficient. Coating on both sides does not seem to give the corresponding advantage. A resin which can be used with advantage to improve strength as well as reduce permeability appears to be the polyurethane.

Conclusions

Low molecular weight acrylic resins particularly butyl acrylate gives a good combination of strength and reduced porosity when applied as a single coat on kraft paper. A 50% increase in strength and 75% reduction in porosity can be obtained. Polyurethane coatings improve even the folding endurance of paper in addition to other properties.

Experimental

Chemicals used were of reagent grade. Monomers were distilled before use.

Polymer lattices based on methyl and butyl acrylate were prepared by emulsion polymerisation of the purified monomers with potassium persulfate as initiator, sodium lauryl sulfate as emulsifier and water. The methods have been described elsewhere[6-8].

Polyurethanes were prepared from polyester polyols and toluene diisocyanate.

TABLE—2 PROPERTIES OF COATED PAPERS

S.No.	Property	Kraft uncoated	A	A+	B	B+	BH	BH+	U
1	Basis weight, g/m²	63	68	72	73	84	69	73	70
2	Burst strength, k Pa × 10⁻²	1.34	2.21	2.29	1.68	1.84	1.53	1.58	2.68
3	Burst factor, k. Pa. m²/g × 10⁻²	2.13	3.40	3.42	2.25	2.19	2.22	2.23	3.23
4	Double folds, MD/CD	50/20	14/10	19/14	30/13	41/15	27/13	25/14	90/40
5	Air permeability × dm³/m³ s. bar + 10⁴	1590	817	444	6.5	4.9	1512	1470	482

+coated on both sides.

The kraft base paper was conditioned at 65% R. H. and 25°C before use. The brush coated papers were reconditioned before testing.

Tappi methods were used for testing and analysis. The viscosity of coatings was measured by Brookfield viscometer. The molecular weights of polymer solids were estimated by viscometery and the published value of constants was used.

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