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(56) Documents Cited:
EP 0385747 A2
Advances in Chemistry Series (1986), 213, 425-33; Poly(2-ethyl-2-oxazoline): a new water- and organic-soluble adhesive.
Polymeric Materials Science and Engineering, (1984), 51, 180-9; Poly(2-ethyl-2-oxazoline) - a new water- and organic-soluble adhesive.

(58) Field of Search:
Other: **ONLINE: WPI, JAPIO, EPODOC, CASONLINE**

(54) Abstract Title: **Polyethyloxazoline adhesives**

(57) Polyethyloxazolines can be used as water-soluble adhesives. A water based liquid adhesive comprises 50-70 % by weight of polyethyloxazoline. A method of applying an adhesive coating to paper applies a solution of polyethyloxazoline to the paper. Preferably the polyethyloxazoline has a molecular weight of less than 500,000 Daltons and a viscosity of 5,000-50,000 MPa.s.

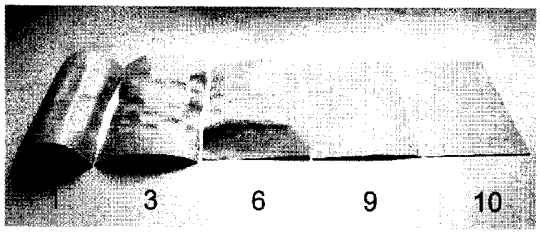

FIG. 1B

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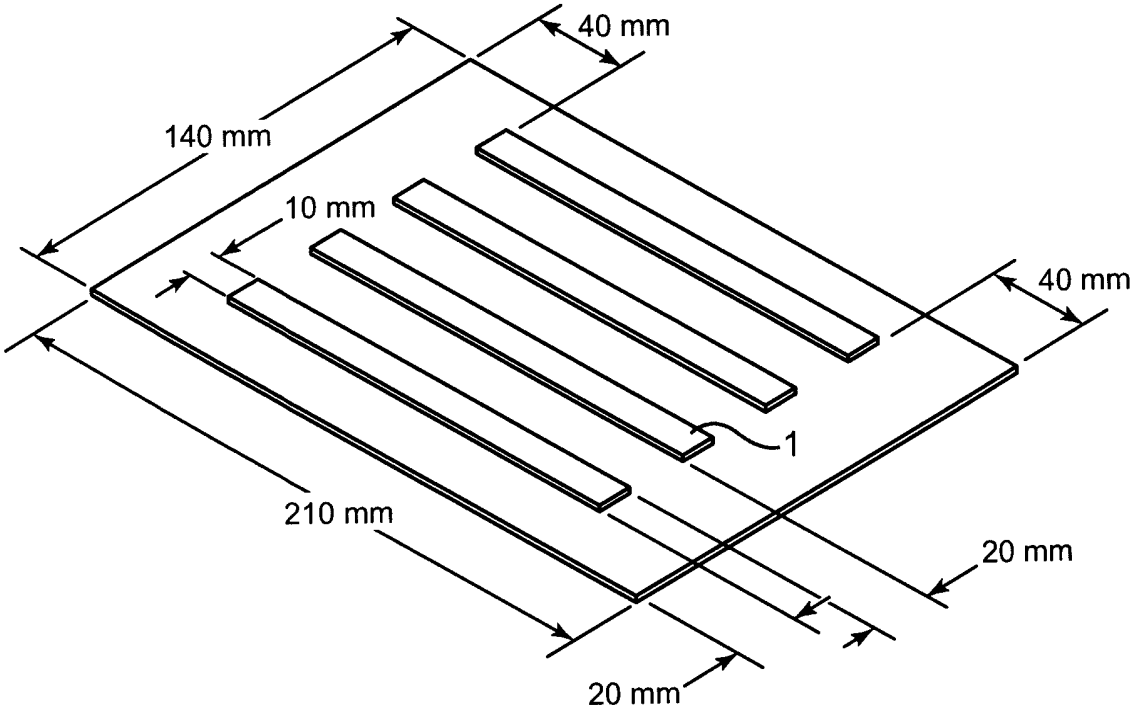


FIG. 1A

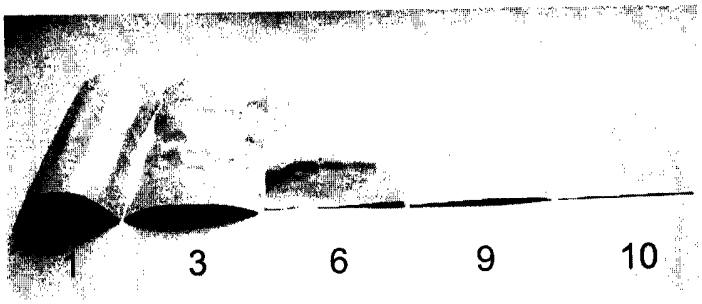


FIG. 1B

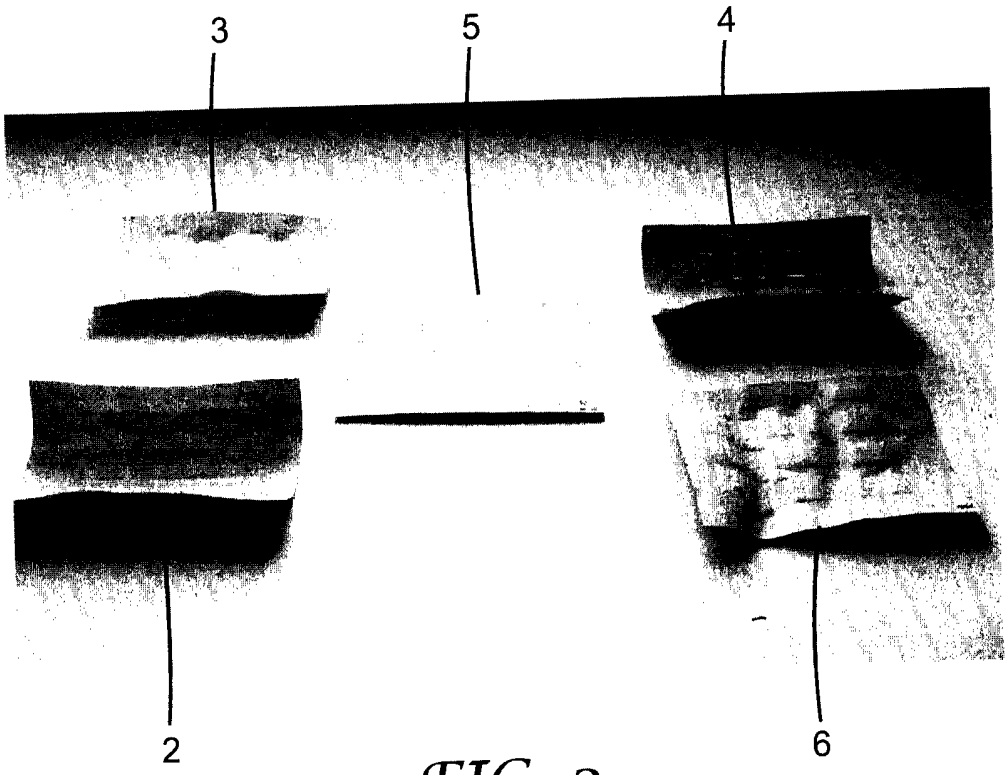


FIG. 2

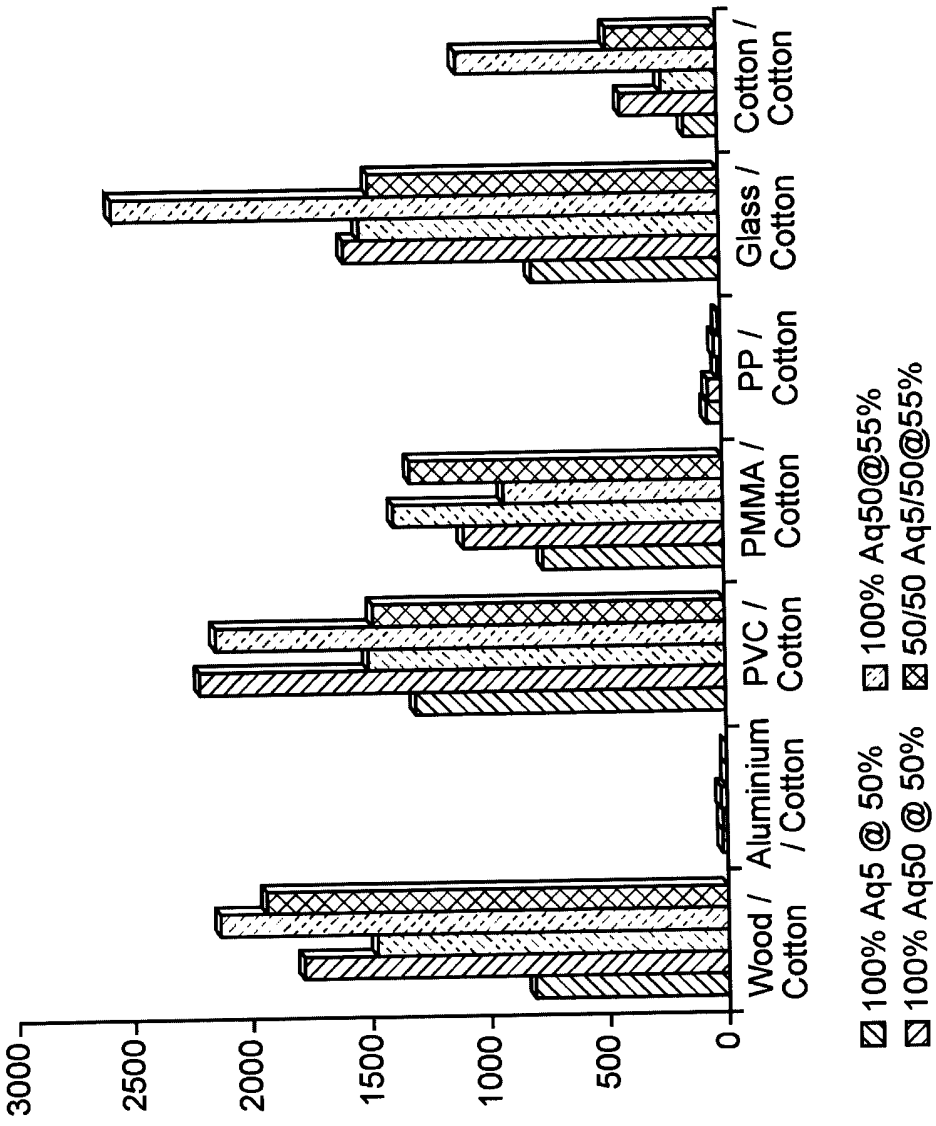

3000
2500
2000
1500
1000
500
0
Wood / Cotton
Aluminium / Cotton
PVC / Cotton
PMMA / Cotton
PP / Cotton
Glass / Cotton
Cotton / Cotton
100% Aq5 @ 50%
100% Aq50 @ 50%
100% Aq5 @ 55%
100% Aq50@55%
50/50 Aq5/50@55%

FIG. 3

WATER-SOLUBLE ADHESIVE

The invention relates to a liquid, water-soluble adhesive, comprising an adhesive polymer dissolved in water. In particular the invention relates to a water-soluble adhesive that when applied to a paper substrate does not cause the paper to wrinkle or at least such wrinkling is minimized.

Adhesives for home activities can be split into two categories: solvent-based adhesives and water-based adhesives. Unless specific performances are required, such as water-resistance or outside usage, water-based adhesives are often preferred to solvent-based adhesives as they are more environmentally friendly.

Water-based adhesives may be prepared by emulsifying a polymer in water, typically ethylene/vinyl alcohol copolymers or polyvinyl acetate, or by dissolving a polymer in water, typically polyvinylpyrrolidone or polyvinyl alcohol, etc.

One disadvantage of the emulsion process is that the adhesive is generally not transparent. Although the adhesive dries to form a clear film, this film is not soluble in water, which means that the adhesive generally cannot be easily washed off clothes or substrates. As such, these adhesives are perceived as dirty to use, and children are generally discouraged to use them.

Although the homogenous medium in the dissolving process provides for a transparent water-based adhesive, the thickener properties of the polymer used make the adhesive very viscous, even at low solids content such as 12-20wt%.

Therefore, when used on paper, a common substrate in home usage, the adhesive's very low solid content and very high water content causes the paper to wrinkle. This distortion stays visible even after the paper has dried. For this reason, water-soluble adhesive does not provide for a precise and clean attachment when used on paper. Furthermore, when used in a notebook, the distortion will be visible from one page to another. As a consequence, children do not use liquid adhesives. Moreover, water-soluble adhesive is unsuitable when a precise application is required, for example scrap booking, as the wrinkles ruin the overall image and disappoint the user.

It would thus be desirable to find a further adhesive composition that does not have one or more of the above-mentioned shortcomings of adhesives known in the art. In particular, it is desirable to find a liquid water-soluble adhesive composition that does not cause a paper substrate to wrinkle or at least such wrinkling would be minimal. Desirably, the adhesive has good or excellent adhesive properties and can be produced in easy and cost effective way. Desirably, the adhesive can be used in home or school activities and /or may be used where clean and precise attachment is desired. Furthermore, it may be desirable to find an adhesive composition that can be delivered to an applicator having small nozzles.

In one aspect, the invention provides a method of applying an adhesive to a paper substrate, the method comprising applying a liquid, water-soluble adhesive composition to the paper substrate, said liquid, water-soluble adhesive composition comprising an adhesive polymer dissolved in water and said adhesive polymer comprising a polyethyloxazoline.

It has been found that the adhesive composition used in the method generally does not cause wrinkling of the paper substrate or alternatively the amount of wrinkling is small. Typically, the adhesive composition can be produced easily and in a cost effective way. Generally, the adhesive can

be delivered through applicators with a small nozzle. The adhesive generally has good adhesive properties and is particularly suitable for adhering a paper substrate to other substrates including paper.

In another aspect, the invention also relates a liquid, water-soluble adhesive composition comprising adhesive polymer dissolved in water, wherein the adhesive polymer comprises one or more polyethyloxazolines in an amount of more than 50wt% and up to 70wt% based on the total weight of the water-soluble adhesive composition.

In one embodiment, the polyethyloxazoline comprises one or more poly(2-ethyl-2-oxazoline) polymer, such as a mixture of two or more poly(2-ethyl-2-oxazoline) polymers with different molecular weights.

The invention further relates to a product comprising an adhesive dispenser that contains a liquid, water-soluble adhesive as hereinbefore defined.

The invention further relates to a method of producing a liquid, water-soluble adhesive as hereinbefore defined, which method comprises dissolving one or more polyethyloxazolines in water, such that the polyethyloxazolines are added so as to be present in the liquid, water-soluble adhesive composition in an amount of over 50 and up to 70wt% based on the total weight of water-soluble adhesive composition.

BRIEF DESCRIPTION OF THE DRAWINGS

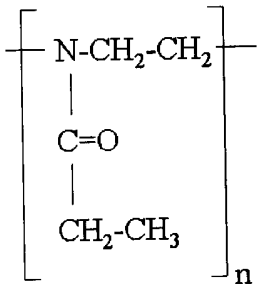
Figure 1 shows a graphical representation of the wrinkle evaluation protocol as herein described.

Figure 2 shows the results of wrinkle analysis with adhesives containing polyethyloxazoline polymers and conventional polymers.

Figure 3 shows a graphical representation of the results of the adhesion analysis obtained in Table 3.

DETAILED DESCRIPTION OF THE INVENTION

Poly(2-ethyl-2-oxazoline) (PEOx; polymers having the formula (I) below:



(I)

are commercially available (Sigma Aldrich) under the name Aquazole™ in a variety of differing molecular weights. For example, Aquazole™ 5 has a molecular weight of 5,000Da (hereinafter referred to as AQ5), Aquazole™ 50 has a molecular weight of 50,000Da (hereinafter referred to as AQ50), Aquazole™ 200 has a molecular weight of 200,000Da (hereinafter referred to as AQ200) and Aquazole™ 500 has a molecular weight of 500,000Da (hereinafter referred to as AQ500). The term "AQ polymers" is used herein not only to generically refer to each of the AQ polymers (AQ5, AQ50, AQ200 and AQ500) but generally also to polyethyloxazoline polymers of formula (I).

Surprisingly, we have found adhesives containing AQ polymers to demonstrate excellent adhesion properties when applied to a paper substrate while only slightly wrinkling or distorting the paper substrate, unlike adhesives containing conventional polymers. Furthermore, the adhesives are

clean to use and because of the minimal wrinkling and distortion caused, the adhesive may be used in precise applications (such as paper crafting).

It will be appreciated that references to "wrinkling" generally refer to the distortion of a paper substrate when subjected to treatment with a water based product (e.g. a water-soluble adhesive). Thus, the term wrinkle may equally be replaced with distort, deform, crease, crumple, fold, furrow, rumple, pucker, curl, cause to curve and the like and each of these terms will be considered as interchangeable.

AQ polymers also have the advantage of possessing low viscosity which allows the adhesives to be formulated with a high concentration of polymer. Thus, in one embodiment, the polyethyloxazoline is present in the adhesive at a level of 30wt% or more. In a further embodiment, the polyethyloxazoline is present in the adhesive at a level of any one of 30, 45, 50, 50.5, 51 or 52wt% to any one of 56, 57, 58, 60, 65wt% or 70wt%. In a particular embodiment, the polyethyloxazoline is present at a level of from 30 to 65wt%, 45 to 65wt%, 50 to 60wt%, 50.5 to 60wt%, 51 to 58wt%, 52 to 57wt% or 52 to 56wt%.

Adhesives containing high solid contents of AQ polymers (e.g. 52 to 65wt%) have advantageously been found to result in extremely low degrees of wrinkling.

In one embodiment, the polyethyloxazoline has a molecular weight of 500,000Da or less. In a further embodiment, the polyethyloxazoline has a molecular weight of 200,000Da or less, such as 50,000Da or less (e.g. 5,000 to 50,000Da).

Adhesives containing AQ polymers with low molecular weights (e.g. 5,000 to 50,000Da) have advantageously been found to prevent wrinkling of paper during and after complete drying. Low molecular weight AQ polymers also

have the advantage of retaining low viscosity properties even when containing a high solids content.

It will be appreciated that the adhesive dispenser may comprise any container suitable for holding the adhesive of the invention. In one embodiment, the dispenser has a nozzle for dispensing the adhesive. In a further embodiment, the nozzle has a flat surface which has the advantage of allowing application of the dispensed adhesive onto a flat surface.

In a further embodiment, the nozzle of the adhesive dispenser has a perforation of from 0.5 to 3mm (e.g. 1.5 to 2mm) for dispensing the adhesive. If the perforation is larger than 3mm then an excess of adhesive is applied on the paper substrate. This creates a disadvantage that the drying time of the adhesive is increased. Furthermore, when two substrates are glued, excessive adhesive will flow out from between the substrates. The small perforation (e.g. 1.5 to 2mm) provides the advantage of ensuring that a suitable quantity of glue is applied on the paper substrate and ensures that the adhesive can be used in high skill artwork. This embodiment, may provide the advantage of creating less spillages which allow safe and clean use by children and infants.

In one embodiment, the adhesive has a viscosity of from 5,000 to 50,000MPa.s. In a further embodiment, the adhesive has a viscosity of from 5,000 to 35,000MPa.s, such as 5,000 to 15,000MPa.s. AQ polymers with low viscosities (e.g. 5,000 to 15,000MPa.s) advantageously provide a beneficial flow of adhesive through the small perforations of nozzles.

The liquid, water-soluble adhesive composition is typically used to glue or adhere a paper substrate to another substrate. The paper substrate can be any paper substrate including sheets of paper, paper in roll form, card-board etc... In a particular embodiment, the adhesive can be applied to paper having a weight between 40 g/m^2 and 200 g/m^2, for example between 60

g/m^2 and 120 g/m^2. The paper substrate may be opaque as well as translucent, such as for example tracing paper, and may be white or colored. Suitable substrates to which the paper substrate may be glued using the adhesive composition include for example other paper substrates, plastic sheets, metal substrates, wood and walls, including walls covered with wall paper.

EXAMPLES

Materials Used

Vinyl Acetate/Vinyl Pyrrolidone copolymer (hereinafter referred to as PVP/VA) was obtained from International Speciality Products Europe, Waterfield, Tadworth, Surrey, KT20 5HQ, UK as product PVP/VA W735.

Polyacrylamides (hereinafter referred to as PAM) were obtained from SNF S.A.S., ZAC de Milieux, 42163 Andrezieux Cedez, France as product DP/MD2237A.

Polyvinylpyrrolidone (hereinafter referred to as PVP) was obtained from BASF Aktiengesellschaft, Functional Polymers Division, New Business Development, ED/N-H201, 67056 Ludwigshafen, Germany as product Luviskol K30 and Luviskol K115.

Polyvinyl alcohol (hereinafter referred to as PVA) was obtained from Celanese Chemicals Europe GmbH, Frankfurter Strasse 111, D-61476 Kronberg/Ts as product CELVOL 205.

Adhesion Measurement Protocol

Adhesion was measured by peeling at 180°C of "Cotton Ref T79" (supplied by DMR Rubans SA, 16, Rue Carnot, 59759 Comines, France), on the following substrates: wood; aluminium; polypropylene (PP); poly methyl methacrylate (PMMA); polyvinyl chloride (PVC); glass and cotton.

A piece of 25 mm width of each substrate and a piece of 25 mm width cotton was weighted, and coated with the adhesive, using a brush. A weight of 2 kg was applied on the assembly during 2 seconds. Then assembly was dried during 24H at room temperature, and weighted again to calculate the dry weight of adhesive coated.

Cotton was peeled from the substrate @ 180°C, 300 mm/min, in a mechanical testing machine (Model 1122 Serie IX, Instron Corporation).

All adhesion results were expressed in cN / cm / g of dry adhesive.

Delamination Measurement Protocol

This test assesses the effectiveness of the adhesive in providing a good adhesion to paper and to evaluate the time needed for paper sheets to be permanently bonded.

The test was made on paper supplied from Meerssen & Palm (Favini Group), Flying Colours Range, Daffodil colour. A sample (21 cm long x 3 cm wide) of this paper was coated with a 100 micron thick layer of adhesive. Another sample, same size, of this paper was applied on the adhesive. A 2 kg rubber roll pressure was applied to the assembly for 2 seconds. After 45 minutes, the assembly was separated. If delamination has occurred then the delamination test provides a "YES". If delamination has not occurred then the delamination test provides a "NO".

Wrinkle Evaluation Protocol

When a liquid, water soluble glue is applied on paper, the distortion that immediately occurs evolves with time, to reach a final, permanent distortion. Given the initial evolution as a function of time, only the final, permanent distortion is evaluated (when the adhesive has been dried).

The test was made on a paper supplied from Meerssen & Palm (Favini Group), Flying Colours Range, Daffodil colour which must have stayed in the test room for at least 24H before the test was conducted.

A sample (21 cm long x 14cm wide) was coated with a 50 & 100 microns thick layer of adhesive, as described in Figure 1A (the adhesive coating is shown by 1 in Figure 1A). A standard Scotch® Removable Magic™ Tape (811), 50 microns thick, supplied from 3M Company, was applied to each area which is not intended to receive adhesive (mask) before coating. Adhesive was then coated manually, with a bar. The mask was then removed just after the adhesive was coated, and specimens are dried during 24H at room temperature onto a flat surface. Samples were turned over (coated side downwards) just before evaluation and final distortion was qualified by the average gap between the flat surface and the sample. Given that the distortion essentially depends upon the nature of the glue (can be curl or waves, or more complex distortions), no measurements were taken but overall distortion was evaluated on a 0-10 scale basis, by comparison with reference specimens (10 was given for a flat paper, 1 was given to an important distortion), as shown in Figure 1B (which shows distortion values of 1, 3, 6, 9 and 10).

Viscosity

Viscosity measurements were made using a Brookfield Viscometer, Model LVF, available from: Fullbrook Systems Limited, Unit 4, Bourne End Mills Ind Est, Upper Bourne End Lane, Hemel Hempstead, Herts, HP1 2UJ. For low viscosities, Spindle 3 was used at 30 revolutions per minute (rpm); for high viscosities, Spindle 4 was used at 60 rpm. All liquids were Newtonian fluids. Viscosity is expressed in units: MPa.s.

Example 1: Delamination and Wrinkle Analysis

A wrinkle analysis was initially performed on conventional polymer containing adhesives (e.g. PVP/VA, PAM, PVP and PVA) and the results are shown in Table 1.

Table 1 Results of wrinkle analysis with adhesives containing conventional polymers

Polymer	% Solid Content	Glass Transition (Tg)	Wrinkles	
			50μm	100μm
PVP/VA	50	114°C	1	0
PVP K30	30	160°C	1	0.5
PVP K115	15	160°C	6	2.5
PVA	21	358°C	3	3
PAM	40	-	1	NT

The results of this analysis demonstrated that there does not appear to be a correlation between the solid content of the polymer within the adhesive and the distortion of the paper substrate. For example, high solid content of PVP/VA and PAM demonstrated equally distorted paper substrate. Furthermore, there does not appear to be a correlation between glass transition (Tg) and wrinkle formation. Low glass transition values are generally possessed by polymers with enhanced flexibility.

Adhesives comprising a variety of compositions of AQ polymers (AQ5, AQ50, AQ200 and AQ500) were also analysed for viscosity, wrinkle formation and delamination and the results are shown in Table 2.

Table 2 Results of viscosity, wrinkle and delamination analysis with adhesives containing AQ polymers

% Composition				% Solid Content	Viscosity	Wrinkles		Delamination
AQ 5	AQ 50	AQ 200	AQ 500			50µm	100µm	
100	0	0	0	50.1	2300	7	9	YES
				55.2	5100	7	7	
				60.4	12200	9	9	
				65.2	29000	10	10	
0	100	0	0	30.3	400	NT	7	
				35.5	800	NT	7.5	
				40.0	1700	NT	8	
				44.4	2600	NT	8	
				50.0	8200	8.5	8	
				55.5	21500	7	7.5	
				64.9	88000	NT	10	
25	75	0	0	50.3	7200	8	NT	
				54.7	13200	7	NT	
50	50	0	0	50.5	4650	7.5	8	
				54.6	9300	7	7	
75	25	0	0	50.4	3650	8	NT	
				54.7	6800	8	NT	
0	0	100	0	29.9	3000	NT	NT	YES
				35.2	6500	NT	5	
				39.9	15500	NT	6	
				44.2	35000	NT	6	
				50.2	78000	NT	7	
0	0	0	100	24.0	3800	NT	NT	YES

NT = not tested

From the results in Table 2 it appears that generally, all concentrations of AQ polymers of varying molecular weight demonstrated good wrinkle prevention and only low concentrations of AQ polymer (below 30wt%) caused distortion of the paper substrate. Optimal results were observed with a high concentration of low molecular weight AQ polymer (e.g. above 50wt% of AQ5 and AQ50) which demonstrated minimal paper distortion. Furthermore, it would appear that the quantity of adhesive (50μm or 100μm) had no significant influence on the distortion of the paper substrate.

Figure 2 graphically depicts the results of the wrinkle analysis with adhesives containing AQ polymers (AQ 5 at 60% solids (shown as 5 in Figure 2)) and comparativel polymers (2 represents 50wt% PVP/VA, 3 represents 21wt% PVA, 4 represents 30wt% PVP and 6 represents 15wt% PVP). The significant wrinkle free properties of the AQ polymers can be observed from Figure 2 when compared with the distortions caused by comparative adhesives.

Example 2: Adhesion analysis

An adhesion analysis was performed on a variety of differing adhesives according to the invention. Adhesives comprising 50wt% AQ5 and AQ50, 55wt% AQ5 and AQ50 and 55wt% AQ5/AQ50 (50/50 mixture) were used in this analysis. The results are shown in Table 3 (and graphically represented in Figure 3) which indicates generally that adhesives comprising the higher molecular weight polymer AQ50 demonstrated greater adhesion than the lower molecular weight polymer AQ5. Furthermore, adhesives comprising a higher solid content percentage of AQ polymer (e.g. 55wt%) generally demonstrated greater adhesion than the lower solid content percentage (e.g. 50wt%).

Table 3: Results of Adhesion Analysis using AQ5 and AQ50

	Wood/ Cotton (A)	Aluminium/ Cotton (B)	PVC/ Cotton (C)	PMMA/ Cotton (D)	PP/ Cotton (E)	Glass/ Cotton (F)	Cotton/ Cotton (G)
100% AQ5 @ 50wt%	812	19	1306	758	62	792	139
100% AQ50 @ 50wt%	1785	18	2212	1094	54	1584	405
100% AQ5 @ 55wt%	1479	24	1503	1391	14	1519	233
100% AQ50 @ 55wt%	2134	0	2144	923	28	2566	1099
50/50 AQ5/AQ50 @ 55wt%	1937	0	1484	1319	10	1476	462

WHAT IS CLAIMED IS:

1. A method of applying an adhesive to a paper substrate, the method comprising applying a liquid, water-soluble adhesive composition to the paper substrate, said liquid, water-soluble adhesive composition comprising an adhesive polymer dissolved in water and said adhesive polymer comprising a polyethyloxazoline.

2. A method according to any one of the preceding claims wherein the total amount of polyethyloxazoline polymer in the water-soluble adhesive composition is from 52wt% to 70wt% based on the total weight of water-soluble adhesive composition.

3. A method according to any one of the preceding claims wherein the polyethyloxazoline has a molecular weight of 500,000Da or less.

4. A method according to any one of the preceding claims wherein the adhesive has a viscosity of from 5,000 to 50,000MPa.s.

5. A liquid, water-soluble adhesive composition comprising adhesive polymer dissolved in water, wherein the adhesive polymer comprises one or more polyethyloxazolines in an amount of more than 50wt% and up to 70wt% based on the total weight of the water-soluble adhesive composition.

6. An adhesive according to claim 5 wherein the adhesive polymer is present at a level of from 52wt% to 70wt%.

7. An adhesive according to any one of claims 5 to 6 wherein the adhesive polymer has a molecular weight of 500,000Da or less.

8. An adhesive according to any one of claims 5 to 7 wherein the adhesive has a viscosity of from 5,000 to 50,000MPa.s.

9. A product comprising an adhesive dispenser that contains liquid, water-soluble adhesive as defined in any one of claims 5 to 9.

10. A product according to claim 9 wherein the dispenser has a nozzle for dispensing the adhesive.

11. A product according to claim 10 wherein the nozzle has a perforation of from 0.5 to 3mm for dispensing the adhesive.

12. A product according to any one of claims 9 to 11 wherein the nozzle has a flat surface for applying the dispensed adhesive onto a surface.

13. A method of producing a liquid, water-soluble adhesive composition as defined in any one of claims 5 to 8, which method comprises dissolving one or more polyethyloxazolines in water, characterised in that the polyethyloxazolines are added so as to be present in the liquid, water-soluble adhesive composition in a total amount of over 50 and up to 70wt% based on the total weight of water-soluble adhesive composition.

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Application No: GB0607626.9 **Examiner:** Mr Jason Scott

Claims searched: 1-13 **Date of search:** 9 August 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-13	Advances in Chemistry Series (1986), 213, 425-33; Poly(2-ethyl-2-oxazoline): a new water- and organic-soluble adhesive. DOW. CHEM., See whole document disclosing the use of poly(2-ethyl-2-oxazoline) as a water soluble adhesive. Although it is not disclosed as being coated to paper, it is obvious to one skilled in the art that paper could be added to the list of named substrates.
X	5-13	Polymeric Materials Science and Engineering, (1984), 51, 180-9; Poly(2-ethyl-2-oxazoline) - a new water- and organic-soluble adhesive. DOW. CHEM., See whole document disclosing the use of poly(2-ethyl-2-oxazoline) as a water soluble adhesive. Although it is not disclosed as being coated to paper, it is obvious to one skilled in the art that paper could be added to the list of named substrates.
X	1-13	EP 0385747 A2 AVERY INTERNATIONAL See whole document disclosing the use of poly(2-ethyloxaline) as an adhesive. The example shows melt compounding, though solution coating using water as a solvent is clearly indicated as an alternate method. The weight ratios would be easily derived by one skilled in the art.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

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