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DEVELOPMENTS IN LATEX APPLICATIONS

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Two of the main objectives of the latex manufacturing industry in recent years have been to establish faster and cheaper processing methods and to improve product performance in line with customer requirements. In facing this challenge, NR has had to compete not only with an increasingly wide range synthetic latices but with materials such as the flexible polyurethanes, which with the aid of new technologies have been able to expand into areas which were formerly the preserve of latex. Despite this, a fairly steady increase in world consumption of NR latex has been achieved, averaging about 5% per annum over the last decade.

In the present paper, particular attention has been devoted to latex carpet backings, since it is in this field that the most rapid and notable latex developments have recently taken place. Some new outlets for NR latex are described and developments in the use of rubber in roads are discussed.

Latex Carpet Backings

The greatly increased use of latex - both natural and synthetic - as a carpet backing material in the last 10 years is due to the rapid growth of the tufted carpet industry. In the U.S.A. it is estimated that about 90% of all carpets are now of the tufted type, and in Western Countries generally continued expansion is forecast for the foreseeable future. At present it is estimated that about 220,000 tons of latex (dry weight) are used in carpet backings, world-wide, of which some 40,000 tons are NR latex. This application is already the most important single outlet for NR latex in the U.S.A. and is certainly a major outlet in many European countries.

The essential function of a latex carpet backing is to ensure adequate tuft anchorage to the base hessian or polypropylene and to give dimensional stability and the necessary degree of stiffness to the carpet. An additional function provided by foam backings is to impart resilience and eliminate the need for separate underlays.

The simplest type of latex backing is the primary backing or anchor coat in which a highly loaded latex compound is spread on the back of the carpet and dried - and if necessary vulcanized. The most popular type of latex for this purpose is carboxylated SBR. It is very simple and safe to compound (the latex has an extremely high mechanical stability), it can accommodate very high filler loadings, and it requires no vulcanization. It thus has the twin merits of cheapness and rapid processing. At NRPRA, non-vulcanizing primary backings based on NR have been developed which are also simple to compound and process, and which give excellent tuft bond strength. They are also less susceptible to deterioration by water than CSBR backings. Technically, the main deficiency of NR primary backings at present is that they are appreciably softer than CSBR backings, though some increase in stiffness can be achieved by incorporating about 10% of polyvinyl acetate latex.

The same non-vulcanizing NR compounds, but containing less filler (usually whiting) are suitable for "secondary" backings in which hessian is laminated to the back of the carpet. The latex in this case serves the dual function of anchoring the tufts to the primary hessian and acting as a laminating adhesive for the secondary hessian. The excellent adhesive properties of NR latex make it very suitable for this application and high peel strengths between carpet and secondary backing can be achieved. Typical formulations for primary and secondary NR latex backings are shown in Tables 1 and 2.

Gelled Foam Backings

In Western countries the greatest growth area in carpet backings is foam backing. In the U.S.A. foam-backed carpet accounted for about 30% of all carpeting in 1972 and it is estimated that this figure should reach nearly 40% by 1977.

Until recently all foam backings were produced by chemical gelation of the wet spread foam, followed by drying and vulcanization, and a large proportion of foam backing is still produced by this method, especially in the U.S.A. The two types of latex used almost exclusively are SBR and NR, often as blends, If a backing with an embossed pattern on it is required, NR latex or at least a blend containing a high proportion of NR is the material of choice because of the need for high wet gel strength, without which the pressure of the embossing rollers can result in rupture of the gel and a poorly defined embossing pattern. Embossed foam backings have proved popular in some European countries. In America, flat foam (no embossing pattern) is much commoner and since high wet gel strength is not so essential in this case, SBR or SBR/NR blends with a high proportion of SBR are normally used.

For the higher density range of backings (38 oz/sq. yard, minimum), specifications exist in the U.S.A. which appear to have succeeded in maintaining quality standards and consumer confidence. Fashion is also important and in America recently there has been a rapid growth in so-called "fat-back" foam which is unusually thick (3/8 inch) and averages about 45 oz./sq. yard. Work at NRPRA has shown that current American specifications for high density flat foam can readily be met using NR latex or NR/SBR blends containing a high proportion of NR. A suitable formulation for either flat or embossed NR foam is given in Table 3.

No-Gel Latex Foams

During the last four years, traditional gelation methods have been challenged by the so-called "no-gel" process for spread foam. The essence of the no gel process is the production of an ultra-stable liquid foam which can be spread on the carpet, dried and vulcanized without a separate gelation stage. Four important advantages accrue from this technique.

(1) the level of process control required is less than for gelling systems.

(2) equipment costs are reduced by elimination of the foaming machine blender which is not needed in the absence of gelling agents.

(3) higher plant running speeds (and therefore higher productivity) are possible due to the higher total solids contents of no-gel formulations.

(4) greater amounts of fillers can be used, thus increasing profit margins.

On the other hand, no-gel foams are much more sensitive to water than gelled foams, due to the relatively large quantities of undecomposed surfactants they contain.

The types of latex mostly used at present in the no-gel process are SBR and carboxylated SBR, but work at NRPRA has resulted in the development of formulations based on NR which produce backings of very good quality. A typical formulation is illustrated in Table 4. During 1972 very similar compounds to the one shown were used successfully in U.K. carpet factories, but interest deminished towards the end of the year as NR prices increased steeply.

Extensive comparisons of the physical properties of NR and SR spread foams, of both the no-gel and gelled types, have been carried out at NRPRA and a brief summary of the results is shown in Table 5. Although in most of the properties examined NR is superior to SBR or CSBR, its lower compression modulus is a disadvantage especially with low density backings, and cheap, effective means of increasing the modulus of the NR foams are being urgently sought. SBR and CSBR foam compounds are also better than NR in respect of processing stability, although considerable improvements in the stability of NR compounds have been made at NRPRA during the last year. So long as NR prices remain at present levels, the best prospects for increased consumption are likely to be in contract work for high quality backings in which such properties as high resilience and strength and low compression set are primary requirements.

Flame-Resistant Latex Products

In recent years there has been a steadily growing concern about the flammability of certain rubber products (and other materials), especially in the U.S.A. The introduction of Federal legislation limiting the flammability of carpets and of materials used in automobile interiors immediately affected such rubber products as latex carpet backings and underlays, moulded foam cushions, and rubberized hair upholstery and padding. The automobile legislation, of course, produced repercussions in all other countries exporting cars to the U.S.A.

The standards of flame resistance demanded by the above specifications were not very high and could be met by simple compounding techniques using relatively small proportions of flame-retarding additives. Within a few months of the proposal of the American specifications NRPRA had developed suitable latex compounds for foam carpet backings and for moulded latex foam cushions. The development of adequately flame-resistant rubberized hair products was more difficult due to the inflammable nature of the fibres, but suitable compounds were available by the time the legislation came into effect. These flame-resistant latex compounds are now in use in the UK and W. Germany.

To date, the American specifications have not been followed by similar requirements in other parts of the world. This situation could change, however, quite rapidly and it is possible that in the near future there may be further demands for rubber products with improved flame resistance, which could necessitate some further research and development work.

Rubberized Gypsum Plaster

Completely new applications for NR latex do not occur very frequently, and the development and commercial use (though on a limited scale at present) of rubberized plaster is therefore noteworthy.

Ordinary gypsum plasters contain as their main ingredient either anhydrous calcium sulphate or calcium sulphate hemihydrate, and the setting of plaster on mixing with water is due to hydration and conversion of the plaster to calcium sulphate dihydrate - gypsum. However, plaster suffers from several deficiencies, particularly in respect of brittleness and inflexibility, and it has now been shown that most of these deficiencies can be overcome by incorporating NR, as latex, in the wet plaster. A practicable way of doing this has been developed and patented by NRPRA. The main problem which had to be overcome was to achieve the necessary very high mechanical and chemical stability of the latex/plaster mixes without detrimentally affecting the setting properties of the plaster.

Typically, incorporation of NR into gypsum plaster produces the following changes in properties:

(a) increased flexibility and extensibility
(b) reduced permeability to gases
(c) reduced water absorption
(d) increased knock resistance
(e) increased adhesive strength to many surfaces
(f) reduced compression modulus and surface hardness

The physical properties of rubberized plaster can be varied over a very wide range, depending not only on the proportion of rubber to plaster and the presence or otherwise of inert fillers or extenders but also, surprisingly perhaps, by control of the rate of setting of the wet compound. Flame-resistance is easily imparted if required. Rubberized plaster is in commercial use in the UK as a surface coating. Other potential applications are as undercoatings for plaster walls, grouting compositions, flexible castings and building sealants.

For coating or undercoating applications, as a mine sealant for example, the dry plaster is mixed with the specially compounded latex and applied preferably by spraying from a mixer/sprayer unit powered by compressed air. Substrates on which suchcoatings can be successfully applied include brickwork, stone, rock strata in mines, concrete, cements, timber, wire mesh and hessian.

For highly flexible rubberized plaster building sealants, the inclusion of an extender such as light mineral oil is desirable. The sealant can then be prepared as a 2-part liquid pack with the plaster suspended in the oil as one part and with the stabilised latex as the other part. Table 6 shows some of the properties of an oil-extended rubberized plaster building sealant, together with the corresponding specification limits for 2-part polysulphide sealants as required by BS 4254. Price-wise, rubberized plaster building sealants should be marketable at less than half the cost of polysulphide sealants.

Pre-compounded and Powdered NR from Latex

A process for making an excellent pre-compounded gum or lightly filled NR from latex for engineering uses was developed some years ago at NRPRA (Smith, J.F., Br. Pat. No. 1 255 354). In this, the vulcanizing ingredients, preferably corresponding to an efficient or semi-efficient vulcanization formulation, are ball-milled into latex which is then coagulated with sodium silicofluoride, washed, dried under conditions which do not cause premature vulcanization, and subjected to light homogenization on the mill. The resulting compound is stable for extended periods at room temperature and when vulcanized gives a rubber having excellent strength properties. The consistency of properties is also much better than can be normally obtained using conventional dry mixing methods.

There is little doubt that this process could be adapted to the production of powdered or granulated rubber. Spray drying of the pre-compounded latex, crumbing of the wet coagulum or mechanical comminution of the dried product are possible routes to this end. An anti-cohesion agent such as silica powder would have to be incorporated at this stage to prevent aggregation. It is significant that a large estate company has announced the availability via a latex process of a free-flowing raw or pre-compounded NR (Marshall S., Rubb. Wld. N.Y., 1970, 162 (6), 49) said to be suitable for injection moulding and is considering large scale production in Malaysia.

The problems which remain to be solved using the pre-compounded latex route are (a) how to achieve improved storage life of the compound, (b) how to incorporate reinforcing fillers into latex and (c) how to overcome processing problems caused by the very high molecular weight of the rubber.

Rubber in Road Surfacing Materials

A considerable amount of literature now exists on the subject of rubber in bituminous road materials and on the changes in the physical properties of bitumen brought about by addition of rubber. It is not the purpose of the present paper to review this literature, but to briefly describe some of the most significant trials with rubberized bitumen which have taken place in the UK in recent years.

In 1971 the UK Road Research Laboratory published a detailed report (RRL Report LR 370) on a number of full-scale road experiments in which rubber had been used. The main findings were:

Mastic Asphalt - Addition of NR prevented or markedly reduced subsequent cracking of the mastic when it was laid over concrete joints or cracks. The best results were obtained when the mastic contained 15% of binder (with 18% of NR on the weight of binder). The evidence suggested that as high a binder content as possible should be used, consistent with resistance to deformation under traffic.

Rolled Asphalt - When laid over concrete, rolled asphalt containing 4% NR in the binder was considerably more resistant to reflection cracking than normal asphalt.

Bitumen Macadam - A substantial increase in the life of bitumen macadam was obtained using 4% of NR in the binder.

Bitumen Surface Dressings - A marked reduction in the tendency of bitumen surface dressings to "fat-up" in hot weather under heavy traffic was shown when 1% to 2% of NR was added to the binder, and initial retention of chippings was better. The addition of rubber showed no apparent advantage on lightly trafficked roads.

Many of these findings have been independently confirmed by the practical experience of other authorities. In several English counties, surface dressings containing rubber have been used for many years. During the decade 1960-1970 one County Council carried out approximately 44 miles of surface dressing with rubberized bitumen, including some 23 miles on concrete surfaces. Bitumen containing 1.5 to 2.0% NR, used with 3/8 inch pre-coated chippings, gave results of consistently good quality. Flushing up of the binder and stripping were significantly less than with non-rubberized dressings of either tar or bitumen. With the use of cones, barriers and positive traffic control it was found possible to eliminate the use of a roller, the action of traffic providing all the compaction necessary and without danger arising from loose chippings.

In several Western countries motorways have reached an age when the need for re-surfacing is becoming increasingly frequent. [The first stretch of motoway in the UK to be re-surfaced with rubberized asphalt was in 1971. This was one of the busiest stretches of the M1, of concrete construction. Because of the large volume of traffic carried and the need to keep the road open as long as possible, re-surfacing was carried out with asphalt in preference to concrete which would have needed too long a curing period. Rubberized asphalt was chosen chiefly to reduce the risk of reflection cracking under the very heavy traffic conditions. After first applying a tack coat of spray grade cationic bitumen emulsion, a 50 mm thick rubberized hot rolled asphalt base course was laid, followed by a 40 mm thick rubberized hot rolled asphalt wearing course. Both were made up in accordance with BS 594 and both contained 4% NR by weight of bitumen binder. The rubber was incorporated as latex (LCS Revertex) which was sprayed on to the hot bitumen - coated stones in the pug mill, using a metering pump and automatic timer to control the amount added. The latex addition time for each batch was 25-30 seconds. Finally, to improve skid resistance, 20 mm pre-coated chippings were applied.] Details of this work have been given very recently by D. Tebbutt ("Queens Highway", April, 1973, page 4).

TABLE 1

NR ANCHOR COAT COMPOUND - NON-VULCANIZING

		Weight
60% NR Latex		166.7
Glofoam HE (25%)	(1)	3.0
'Tetron'	(2)	1.0
50% Antioxidant dispersion	(3)	2.0
10% Thiourea solution		10.0
Whiting 3ML	(4)	400.0
10% Thickener solution	(5)	4.0 (or as desired)
Water		to 75% TSC

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(1) Glofoam HE is a sulphated alkyl phenol ethylene oxide condensate having approx. 9 ethylene oxide units.

(2) 'Tetron' is tetra sodium pyrophosphate.

(3) Antioxidant - UOP26 or Flexone 6H will give the best high temperature (>100°C) performance but many other antioxidants will give good results at lower temperatures.

(4) Whiting - a reasonably fine particle size is desired since very coarse grades may give poorer results.

(5) Thickeners - polyacrylates are preferred but are not essential.

TABLE 2

NR LATEX SECONDARY BACKING ADHESIVE - NON-VULCANIZING

		Weight
60% NR Latex		166.7
Glofoam HE (25%)	(1)	3.0
10% Thiouea solution		10.0
'Tetron'	(2)	1.0
Whiting 3ML	(3)	300.0
10% Thickener solution	(4)	3.0 (or as desired)
50% Antioxidant dispersion	(5)	2.0
Water		to 75% TSC

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(1) Glofoam HE is a sulphated alkyl phenol ethylene oxide condensate containing approx. 9 units of ethylene oxide.

(2) 'Tetron' is tetra sodium pyrophosphate.

(3) Whiting - a fairly fine grade will give better results than a very coarse grade.

(4) Thickeners - Polyacrylates are preferred but are not essential.

(5) Antioxidant - UOP26 or Flexone 6H will give the best high temperature performance (>100°C) but many other antioxidants will give good results at lower temperatures.

This compound has given delamination values of >3.5 lbs per inch (Hessian/polypropylene) in the NRPRA laboratories.

TABLE 3

EMBOSSED OR FLAT FOAM BACKING COMPOUND

Formulation:		Weight
High-Ammonia Latex		166.7
20% Soap solution	(1)	15.0
50% Sulphur dispersion		5.0
50% Zinc diethyl dithiocarbamate dispersion		2.0
50% Zinc mercapto benzthiazole dispersion		2.0
50% Antioxidant dispersion	(2)	2.0
Filler	(3)	150.0
Water		16.0
50% Zinc oxide dispersion		6.0
10% Ammonium acetate solution		20.0

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(1) Potassium soaps prepared from 'broad-cut' oleic acids are preferred but coconut oil soap may also be used.

(2) Flectol H and Agerite AK are effective antioxidants but many others may be used if desired.

(3) Fillers such as whitings, calcites, dolomites, and felspars have all been used satisfactorily in this process.

TABLE 4

NR LATEX NO-GEL FOAM CARPET BACKING COMPOUND

	Parts by Weight
60% NR Latex (pentachlorphenate preserved)	166.7
Alcopol FA	12.0
Empicol LX 28	3.6
20% solution of Potassium Oleate	5.0
20% Vulcastab LW solution	5.0
Tetra sodium pyrophosphate	1.0
50% Sulphur dispersion	4.5
50% ZDC dispersion	3.0
50% ZMBT "	3.0
50% ZnO "	6.0
50% Antioxidant dispersion	3.0
Filler	100-200
Acrylic Thickener	as required
Water	to give 75% TS

Materials

Alcopol FA is believed to be the sodium salt of octadecyl sulphosuccinamic acid and is sold by Allied Colloids Ltd., Low Moor, Bradford BD12 OJZ, U.K.

Empicol LX 28 is believed to be a 28% paste of a sodium lauryl sulphate prepared from a narrow-cut lauryl alcohol. It is supplied by Albright & Wilson, Marchon Division, Whitehaven, England.

Vulcastab LW is believed to be a cetyl/oleyl alcohol fraction condensed with an intermediate number of ethylene oxide units (probably 18-20). It is supplied by I.C.I. Ltd.

N.B.

Water is added to the compound where necessary to adjust the Total Solids Content to 75%.

The amount of thickener required will depend on the grade and quantity of filler used, but sufficient is used to adjust the viscosity of the full compound to 3,000 - 4,000 cps. as measured on the Brookfield LVT viscometer at 30 rpm using Spindle No. 3

TABLE 5

Comparison of NR and SR Spread Foam

(gelled or no-gel)

Property	NR compared to SR (SBR or CSBR)
Delamination strength	superior
Compression modulus - unflexed	inferior
- flexed	inferior
Dynamic set	superior
Resilience	superior
Tear strength	superior
Stress decay	superior
Hysteretic loss	superior
Processing stability	inferior

(Compared at same filler level and same foam density)

TABLE 6

Properties of Rubberized Gypsum Plaster Building Sealant (RGPBS) in Concrete/Concrete Test Joints

Property	BS4254 Requirement	RGPBS Performance
Application Life	2hrs min.	up to 6hrs
Elongation	150% min.	250-350%
Force for 150% elongation	5lbs min. 60lbs max.	20-30lbs
Plastic deformation	50% max	<25%
After 7days water immersion		
Elongation	150% min.	>300%
Force for 150% elongation	5lbs min. 60lbs max.	10-20lbs
After heat ageing 7 days at 70°C		
Elongation	100% min.	200-300%
Force for 100% elongation	5lbs min. 60lbs max.	40-50lbs