THE SPECIFIC GRAVITY OF PRESERVED LATEX

BY

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The Journal of the Rubber Research Institute of Malaya, 5, 1934, 234, contained a paper (1) on the specific gravity of preserved latex written by the writer of this note. The paper has recently been made the subject of constructive comment by De Vries (2).*

As a result of the examination of 852 samples of preserved latex, a specific gravity dry rubber content table was derived for preserved natural latices, and the dry rubber content range covered was wide enough to include natural unconcentrated latex in all the phases in which it is likely to be required by or become available to the commercial user. By the unavoidable expedient of extrapolation from the experimental results, a value of 0.902 was also derived for the specific gravity of the rubber phase in preserved latex. This value was in good agreement with the figure of 0.901 obtained by Scholz and Klotz (3) for "rubber" in fresh latex. On the other hand, De Vries (4 and 5), working with fresh latex had prevously derived a value of 0.914 for the specific gravity of the rubber phase, and the specific gravity table used by the Rubber Trade Association of London for preserved latex gives on straight line extrapolation a value of 0.912. It seemed that the value indicated by the work of De Vries and that deduced from the table of the Rubber Trade Association were probably rather high, and certain experiments with centrifugal concentrate and centrifugal concentrate-skim mixtures were cited which provided some confirmatory evidence of this conclusion.

In his recent communication to *The India-Rubber Journal*,† De Vries has pointed out that Rhodes, like Scholz, determined dry rubber contents as weight percentages, and extrapolated the relationship between these values and specific gravity as a straight line; he makes the point that this procedure is not strictly accurate, for whereas the relationship between the dry rubber content of a latex when expressed as a volume percentage, and its specific gravity can be represented by a straight line, the relationship

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between specific gravity and dry rubber content expressed as a weight percentage is not a linear one, and takes the form of a very slightly curved line. The effect of the slight curvature would be to give a higher result for the specific gravity of the rubber phase. He suggests, therefore, that the value of 0.902 derived by Rhodes as a result of straight-line extrapolation is probably slightly low. The formula

$$S_l = \frac{(C_r + C_s)(S_r S_s)}{C_r S_s + C_s S_r}$$

S_l = specific gravity of latex
C_r = weight percentage rubber
C_s = „ „ serum
S_r = specific gravity rubber phase
S_s = „ „ serum phase

covers the relationship between the specific gravities of the rubber and serum phases, the weight percentage of dry rubber and the specific gravity of the whole latex, and by applying it to two pairs of the experimental results published by the writer, De Vries has estimated that a value of 0.9065 for the specific gravity of the rubber phase is probably more accurate than the published figure of 0.902.

The criticism made by De Vries is sound, and it is necessary to correct for the non-linear relationship between weight percentage of dry rubber and the specific gravity of the latex. The experimental results are accordingly analysed in the following pages in the light of De Vries' suggestion.

The Specific Gravity of the Rubber and Serum Phases of Latex

The experimental group-mean points which appear in Table II of the original publication (1) are set out below for easy reference; from these it is possible to calculate values for the specific gravity of "rubber" and serum using the formula

$$S_l = \frac{(C_s + C_r)(S_s S_r)}{C_r S_s + C_s S_r}$$

to which reference has been made earlier.

A value for the specific gravity of the rubber phase and a value for that of the serum phase can be obtained by calculation from any pair of the results in Table I. There are eleven group-mean points, so that it is possible to choose fifty-five different combinations of two D.R.C. points for purposes of calculation. In making his rough estimate of the probable specific gravity values, De Vries made calculations from two pairs only. In order to arrive

TABLE I.

Group D.R.C. per cent. dry weight.	Total samples in Group.	Mean D.R.C. per cent. by weight.	Mean Specific Gravity.
28.1—30.0	97	29.3	0.9831
30.1—32.0	116	31.0	0.9820
32.1—34.0	47	33.0	0.9796
34.1—36.0	59	35.2	0.9773
36.1—38.0	117	37.3	0.9744
38.1—40.0	102	39.1	0.9725
40.1—42.0	104	40.9	0.9706
42.1—44.0	39	43.0	0.9682
44.1—46.0	38	45.2	0.9650
46.1—48.0	85	47.1	0.9626
48.1—50.0	48	48.8	0.9614

at an accurate value it is necessary, as he suggests, to take the average of a larger number of pairs. Calculations have been made from fifty-three of the fifty-five possible pairs, and an average value for the specific gravity of the rubber phase and that of the serum phase obtained. The two pairs which were left out of consideration were the D.R.C. pairs 29.3.-31.0 and 47.1-48.8, which lie at the extreme ends of the D.R.C. range. Every other possible combination was included in the calculation. Table II gives a list of the combinations and the values obtained.

TABLE II

Calculation of values for specific gravity of rubber (S_r) and specific gravity of serum (S_s) from the eleven experimental points of Table I by the application of the formula:—

$$S_1 = \frac{(C_r + C_s)S_rS_s}{C_rS_s + C_sS_r}$$

Total number of pairs	D.R.C. pairs. A	D.R.C. pairs. B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
1	29.3	33.0	.9219	1.0108
2	29.3	35.2	.9178	1.0129
3	29.3	37.3	.9112	1.0164
4	29.3	39.1	.9114	1.0160
5	29.3	40.9	.9115	1.0161
6	29.3	43.0	.9107	1.0165
7	29.3	45.2	.9074	1.0183
8	29.3	47.1	.9064	1.0187

Total number of pairs	D.R.C. pairs. A	B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
9	29.3	48.8	.9087	1.0176
10	31.0	33.0	.9054	1.0206
11	31.0	35.2	.9101	1.0181
12	31.0	37.3	.9047	1.0212
13	31.0	39.1	.9065	1.0200
14	31.0	40.9	.9077	1.0194
15	31.0	43.0	.9076	1.0196
16	31.0	45.2	.9045	1.0212
17	31.0	47.1	.9039	1.0217
18	31.0	48.8	.9067	1.0201
19	33.0	35.2	.9142	1.0156
20	33.0	37.3	.9044	1.0212
21	33.0	39.1	.9069	1.0199
22	33.0	40.9	.9087	1.0197
23	33.0	43.0	.9080	1.0192
24	33.0	45.2	.9045	1.0215
25	33.0	47.1	.9038	1.0218
26	33.0	48.8	.9068	1.0199
27	35.2	37.3	.8951	1.0286
28	35.2	39.1	.9032	1.0229
29	35.2	40.9	.9061	1.0207
30	35.2	43.0	.9065	1.0205
31	35.2	45.2	.9027	1.0232
32	35.2	47.1	.9023	1.0236
33	35.2	48.8	.9059	1.0210
34	37.3	39.1	.9124	1.0156
35	37.3	40.9	.9076	1.0104
36	37.3	43.0	.9103	1.0161
37	37.3	45.2	.9047	1.0108
38	37.3	47.1	.9036	1.0222
39	37.3	48.8	.9075	1.0191
40	39.1	40.9	.9120	1.0156
41	39.1	43.0	.9094	1.0178
42	39.1	45.2	.9024	1.0234
43	39.1	47.1	.9018	1.0239
44	39.1	48.8	.9067	1.0199
45	40.9	43.0	.9073	1.0198
46	40.9	45.2	.8989	1.0273
47	40.9	47.1	.8994	1.0269
48	40.9	48.8	.9058	1.0212
49	43.0	45.2	.8916	1.0353
50	43.0	47.1	.8957	1.0310

Total number of pairs	D.R.C. pairs. A	B	S.G. Rubber (S_r)	S.G. Serum. (S_s)
51	43.0	48.8	.9052	1.0215
52	45.2	47.1	.9003	1.0259
53	45.2	48.8	.9130	1.0127
53	Total	...	48.0388	54.0609
	Average Values	...	0.9064	1.0200

It will be seen that the final average value for the specific gravity of the rubber phase is 0.9064, and that for the serum phase 1.0200. The value of 0.9019 for the specific gravity of the rubber phase is, therefore, corrected to 0.9064.

It now becomes necessary to discover whether or not this correction will have an appreciable effect on the table of figures published as Table V in the original publication (1) for normal preserved latex in the dry rubber content range 28-52%.

Specific Gravity Table for Normal Preserved Latex

By substituting the values 0.9064 and 1.0200 for S_r and S_s respectively, in the formula to which reference has been made, it is possible to calculate values for the specific gravities of latices of any dry rubber content. In this way a specific gravity table can be constructed on the basis of the corrected values for comparison with Table V (1) obtained originally from the straight line $S = -0.001158t + 1.0177$. In Table III this comparison is made.

TABLE III

Showing comparison of values for specific gravity derived from:—

(*a*) the straight line $S = -0.001158t + 1.0177$ (Table V (1)) and

(*b*) from the formula $S_1 = \dfrac{(C_s + C_r) \times 0.9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$

	D.R.C. per cent. by weight.	Specific Gravity. From (*a*) above.	From (*b*) above.
	1	2	3
Experimental zone—	**28.0**	**0.9853**	**0.9854**
	29.0	**0.9841**	**0.9842**
	30.0	**0.9830**	**0.9830**
	31.0	**0.9818**	**0.9819**

	D.R.C. per cent. by weight.	Specific Gravity. From (*a*) above.	Specific Gravity. From (*b*) above.
	1	2	3
Experimental zone—	**32.0**	**0.9806**	**0.9807**
	33.0	**0.9795**	**0.9795**
	34.0	**0.9783**	**0.9783**
	35.0	**0.9772**	**0.9771**
	36.0	**0.9760**	**0.9760**
	37.0	**0.9749**	**0.9748**
	38.0	**0.9737**	**0.9736**
	39.0	**0.9725**	**0.9725**
	40.0	**0.9714**	**0.9714**
	41.0	**0.9702**	**0.9701**
	42.0	**0.9691**	**0.9690**
	43.0	**0.9679**	**0.9678**
	44.0	**0.9667**	**0.9667**
	45.0	**0.9656**	**0.9655**
	46.0	**0.9644**	**0.9644**
	47.0	**0.9633**	**0 9633**
	48.0	**0.9621**	**0.9621**
	49.0	**0.9610**	**0.9610**
	50.0	**0.9598**	**0.9598**
Extrapolation zone—	51.0	0.9586	0.9587
	52.0	0.9575	0.9576
	53.0	0.9563	0.9564
	54.0	0.9552	0.9553
	55.0	0.9540	0.9542
	56.0	0.9529	0.9531
	57.0	0.9517	0.9520
	58.0	0.9505	0.9508
	59.0	0.9494	0.9498
	60.0	0.9482	0.9487
	61.0	0.9471	0.9476

The figures in lighter type are obtained by extrapolation beyond the experimental zone.

The values already published in Table V of the original publication (1) are set out in column 2, while column 3 gives the values derived from the corrected specific gravities of "rubber" and serum.

It is at once apparent that over the whole of the experimental zone, the two tables are to all intents and purposes identical, and that not until by extrapolation a dry rubber content of 57% is reached do appreciable differences begin to be apparent.

In Table IV of the original publication (1) figures were given for the closeness of approach of the experimental points to the line $S = -0.001158t + 1.0177$, and these are again set out in Table IV below in comparison with values derived from the corrected specific gravities for "rubber" and serum.

TABLE IV

Closeness of approach of the group-mean points to :—

(*a*) the line $S = -0.001158t + 1.0177$ (Table IV (1)) and (*b*) values derived from the formula:—

$$S_1 = \frac{(C_s + C_r) \times .9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$$

Mean D.R.C.	Mean S.G. experimental.	S.G. calc. from (*a*) above.	Deviation from exptl. S.G.	S.G. calc. from (*b*) above.	Deviation from exptl. S.G.
29.3	0.9831	0.9838	+0.0007	0.9839	+0.0008
31.0	0.9820	0.9818	−0.0002	0.9819	−0.0001
33.0	0.9796	0.9795	−0.0001	0.9795	−0.0001
35.2	0.9773	0.9769	−0.0004	0.9769	−0.0004
37.3	0.9744	0.9745	+0.0001	0.9744	nil
39.1	0.9725	0.9724	−0.0001	0.9724	−0.0001
40.9	0.9706	0.9703	−0.0003	0.9703	−0.0003
43.0	0.9682	0.9679	−0.0003	0.9678	−0.0004
45.2	0.9650	0.9654	+0.0004	0.9653	+0.0003
47.1	0.9626	0.9632	+0.0006	0.9632	+0.0006
48.8	0.9614	0.9612	−0.0002	0.9612	−0.0002

It will be seen that there is no appreciable difference between the closeness of approach of the two sets of calculated values to the experimental points.

It is, therefore, clear that the original specific gravity table is accurate in the D.R.C. range 28-52%, which covers all commercial requirements for unconcentrated preserved latex. The straight line $S = -0.001158t + 1.0177$ does, in fact, give an accurate picture of the results over the whole experimental range.

It is next required to consider whether or not the substitution of the corrected value for the specific gravity of the rubber phase of latex, weakens materially the deductions which were made in the original publication from the experimental work on settled latex and centrifugal concentrates.

The Specific Gravity of Settled Latex, Centrifugal Concentrates and Centrifugal Concentrate-skim Mixtures

(*a*) *Settled latex and individual samples of concentrate*

In Section B of the original publication (1) it was shown that, by simple gravitational settlement of sludge, specific gravity differences of the order of −0.004 could be observed, and a series of sixty-eight samples of centrifugal concentrate were examined for dry rubber content and specific gravity in order to discover the deviation of the specific gravity from that indicated for normal preserved latex by extrapolation of the straight line $S = -0.001158t + 1.0177$. It was found (see Table VII (1)) that the deviation of specific gravity was of the same order, but in general slightly greater than that observed when normal preserved latex is allowed to undergo gravitational settlement. Table V reproduces Table VII of the original publication (1), together with figures showing the deviation of the experimental results from the specific gravities which are calculated from the corrected values for "rubber" and serum.

TABLE V

Deviation of the specific gravities of centrifugal concentrates from:—

(*a*) the line $S = -0.001158t + 1.0177$ (Table VII (1)) and
(*b*) values derived from the formula:—

$$S_1 = \frac{(C_s + C_r) \times 0.9064 \times 1.0200}{C_r \times 1.0200 + C_s \times 0.9064}$$

Group D.R.C.	No. of samples examined.	Mean D.R.C.	Mean S.G. found.	S.G. Calc. from (*a*)	S.G. Calc. from (*b*)	Deviation from (*a*)	Deviation from (*b*)
56.1—58.0	6	57.2	0.9476	0.9515	0.9518	−0.0039	−0.0042
58.1—59.0	10	58.6	0.9458	0.9498	0.9502	−0.0040	−0.0044
59.1—60.0	21	59.6	0.9442	0.9487	0.9491	−0.0045	−0.0049
60.1—61.0	31	60.4	0.9426	0.9478	0.9482	−0.0052	−0.0056
				Average ...		−0.0044	−0.0048

The use of the corrected values for the specific gravity of "rubber" and serum, increases the deviations slightly, but they remain of the same order as those observed for the gravitational settlement of normal latex, namely, −0.004 to − 0.005.

It was further argued that if the experimental specific gravity values for centrifugal concentrate had been related not to the values derived from the work under reference, but to those obtained

by the extrapolation of the table of the Rubber Trade Association or to those of De Vries, the deviations observed would have been of the higher order of − 0.01. This argument is seen from Table V to require no modification.

With reference to the value of 0.912 derived from the R.T.A. table for the specific gravity of the rubber phase, it should be noted incidentally that this value is obtained by straight-line extrapolation, and since it is equally the practice of the Rubber Trade Association and the Rubber Research Institute to express dry rubber content as a weight percentage, the figure of 0.912 becomes subject to correction in order to make it comparable with the corrected value of 0.9064 now derived from the figures in Table I. When this correction is applied the approximate R.T.A. values for the specific gravities of the "rubber" and serum phases of latex become 0.916 and 1.0133 respectively.

(b) Centrifugal Concentrate-Skim Mixtures

In the original publication, a series of mixtures were made from a quantity of a single centrifugal concentrate of 56.7% dry rubber and its own skim latex, of which the dry rubber content was 15.7%. Dry rubber content-specific gravity relations were obtained for the two primary materials and twelve different mixtures. From these figures a straight-line extrapolation gave a value for the specific gravity of the rubber phase in this concentrate of 0.8966, which deviated by — 0.0053 from the value of 0.9019, which had been similarly derived for "rubber" in normal preserved latex. This deviation was of the same order as that observed for settled latices and individual samples of centrifugal concentrate. The substitution of the De Vries value of 0.914 or the R.T.A. value of 0.912 for the figure of 0.9019 would have given deviations of the order of 0.017 and 0.015 respectively, and this was taken as a further indication that the De Vries value and R.T.A. derived value were probably high.

The value of 0.8966 was derived by straight-line extrapolation from D.R.C. values expressed as a weight percentage, and it therefore requires to be corrected. The fourteen experimental points permit calculations of the specific gravity of the rubber disperse phase to be made from ninety-one different combinations of two D.R.C. points using the formula $S_1 = \frac{(C_r+C_s)\,S_sS_r}{C_rS_s + C_sS_r}$ and the average value for the specific gravity of the rubber phase in the latex concentrate is found in this way to be 0.9011, which deviates from the similarly corrected value of 0.9064 for rubber in normal preserved latex by — 0.0053. This deviation is identical with the figure obtained in the original publication (1). The

deviations from the De Vries value of 0.914 and the corrected R.T.A. value of 0.916 are 0.013 and 0.015 respectively, which are also of the same order as those cited originally. The results obtained by the substitution of corrected for the original values do not, therefore, demand a change in the deductions which were originally made.

Discussion and Conclusions

At the instigation of De Vries, the experimental results which led to the deduction that the specific gravity of the rubber phase of preserved latex was 0.902 have been carefully re-examined, and the value is now corrected to 0.9064. The difference between this corrected value and De Vries' own figure of 0.914, obtained, it should be noted, on fresh latex, is still a large one, and of the order of 0.008. Similarly, the difference between the value of 0.9064 and the corrected value of 0.916 derived from the R.T.A. table remains of the order of 0.01. A re-examination of the supporting evidence advanced in Section B of the writer's original publication does nothing to weaken it, and the reasons for the differing results must for the present remain a matter for some conjecture. De Vries worked with fresh latex of low dry rubber content at a time when it was by no means easy to obtain a rubber-rich material, and he has advanced this and a number of other factors which are possibly contributory to the difference between his final results and those now indicated. There can be no doubt that the specific gravity of the serum must be reduced by the addition of ammonia solution as a preservative. In the original publication no stress was laid on the value for the specific gravity of the serum, because it was felt that it could not be comparable with that of the fresh latex used by De Vries. In our work, however, no added water, except that which is contained in the ammonia solution itself, was present in the samples. De Vries indicates that a low value for the specific gravity of the rubber phase might be expected when the ratio rubber/serum is high, and also enquires what effect on the specific gravity of the "rubber" would be produced by allowing the latex to deposit its phosphates and sludge. Centrifugal concentration provides an artificial combination of the two effects, namely, that of increasing the ratio rubber/serum, and removing extraneous solid matter. In our work on individual samples of centrifugal concentrate this treatment is seen to result in specific gravities lower than those derived for normal latex of the same D.R.C., and in the work on concentrate-skim mixtures the derived value of 0.9011 for the rubber phase itself is also below that of 0.9064 for normal preserved latex. These experiments provide a general indication of the combined effect of the two

factors mentioned, but they do not fully disentangle the effects due to each. It should be mentioned that the determinations made in our work were not made on freshly ammoniated samples. In the original paper (1) it was not pointed out that the samples were examined after periods of time varying from a week to three weeks; the exigencies of other work made it quite impossible to work to a standard storage period. It may be taken, however, that although the samples were not stored for such a long period after preservation as would be the case with latex available for experiments in Europe, they were not examined until the rapid initial changes in D.R.C. noted by Bishop and Fullerton (6) had taken place, and the latex had reached the state in which subsequent change in D.R.C. is slow. In this respect, therefore, our work was not comparable with that of De Vries, and this may account in great part for the difference between his value for the specific gravity of the rubber phase and our own. If one considers the specific gravity table of the R.T.A. in conjunction with the corresponding values in Table III, it will be seen that although the R.T.A. table is based on different values for the specific gravities of the ultimate rubber and serum phases of latex, the figures for commercial latices in the zone covered by the R.T.A. table differ but slightly from those set out in Table III. The values of the R.T.A. were presumably intended only for approximate commercial purposes, and it is unlikely that the differences which do show themselves will disturb either dealers or industrial users.

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