

Chemistry. — "*On the viscosity of rubber in ordinary and in acidified benzene*". By O. DE VRIES. (Communicated by Prof. P. VAN ROMBURGH).

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Viscosity determinations regularly made in our investigations on the preparation of rubber led us to formulate the following three groups of factors as having an influence on the viscosity of 1 % solutions of rubber in benzene (benzol)¹⁾:

1. By-substances of the rubber such as traces of coagulants or other chemicals, serum substances or their decomposition-products etc. These substances generally are also positive or negative catalysts of vulcanisation; they have an influence, therefore, on the rate of cure and the viscosity of the rubber, but leave the mechanical properties after vulcanisation (tensile strength and slope of the stress strain curve) unchanged.

2. Physical or mechanical changes in the colloidal rubber mass, by which the chemical composition of the rubber remains unchanged, but the consistency changes. These are accompanied by changes in swelling properties and in viscosity, but the rate of cure and the mechanical properties after vulcanisation remain unchanged. Into this group have to be brought the changes caused by heating (oxidation being excluded), plasticising and similar operations.

3. Changes in the rubber-hydrocarbon. These may be of two types, viz:

- a. the rubber contains a hydrocarbon of other composition;
- b. the rubber contains the normal hydrocarbon but it is decomposed (depolymerised, oxidised etc.).

The first case might perhaps furnish the explanation of the deviating properties of rubber from young trees, though proofs have not yet been produced. The second case includes different forms of tackiness and decay, by which the quality of the rubber deteriorates very much. These factors not only cause a marked decrease in viscosity, but also in the mechanical properties after vulcanisation; the rate of cure is also sometimes affected.

¹⁾ Archief voor de Rubbercultuur 2 (1918), 474; „Estate Rubber, its Preparation, Properties and Testing" (1920), page 592.

The differences in viscosity, which may be observed in different types of rubber, can nearly always be explained by one or more of the above groups of factors; it is, of course, possible that there are still other causes of changes in viscosity, not enumerated above.

To demonstrate that traces of different chemicals, as meant in group 1, may indeed influence the viscosity in benzene solution, we made in the beginning of 1918 some preliminary experiments by adding to 25 cc. of a 1 % rubber solution in benzene one or two drops of acetic acid, hydrochloric acid, ammonia, formalin or watery solution of different salts. It was found ¹⁾ that indeed the viscosity increased or decreased just as when the same substances were added to the latex or to the rubber, and that the traces of these chemicals, taken up by the benzene-solution, influenced the viscosity to a marked degree.

These findings caused W. A. N. EGGINK ²⁾ to make an extensive series of experiments on the influence of different electrolytes on the viscosity of rubber in benzene. EGGINK showed that benzoic acid, acetic acid, sulphurous acid, mercuric chloride, hydrochloric acid and hydrogen sulphide decrease the viscosity, while ammonia first gives an increase and, in greater concentration, a small decrease; he determined the curves for different concentrations of these electrolytes. In his conclusions EGGINK puts the question whether a determination of the viscosity of rubber in acidified benzene might not be of importance in the testing of rubber, because the rubber in such a solution is discharged and only shows the viscosity caused by its solvation, while the increase in viscosity caused by the electric charge is taken away.

An investigation in this direction seemed to us to be very promising; we investigated in the first place the way in which the factors which belong to the above meant three groups influence the viscosity in acidified benzene. It was found that the influence of chemicals and other by-substances (factors from group 1) may indeed be distinguished in a striking manner from the factors belonging to groups 2 and 3.

1. *Methodical.*

EGGINK used for his investigations one sample of pale crepe, and dissolved about 1 gram in about 500 cc. benzene (the exact rubber

¹⁾ "Estate Rubber", page 573.

²⁾ Rec. Trav. Chim. Pays Bas 62 (1923), 317.

content of the solutions was evidently not determined; it differed somewhat in different experiments, as may be seen from the differences in viscosity, but will have remained in the neighbourhood of $\frac{1}{2}$ %). The tests were made at 25° C. For obvious reasons we preferred to use solution of 1 % tested at 30° C. after the prescriptions for viscosity determinations in use at the Rubber Experimental Stations ¹⁾).

Hydrochloric acid was found, in EGGINK's investigations, to have the strongest discharging influence; at a concentration of about $1\frac{1}{2}$ —2 millimol per liter the viscosity had decreased to a nearly constant value. We commenced our investigations therefore with benzol-hydrochloric acid and investigated how the viscosity changes with larger doses of hydrochloric acid than used by EGGINK. It was found that at higher concentrations (we generally used concentrations up to 75 millimol hydrochloric acid per liter) the viscosity remained also constant; at a concentration of about 5—10 millimol of hydrochloric acid per liter one is safely in the discharged zone, and relatively large differences in concentration of hydrochloric acid have therefore no influence on the viscosity. We therefore chose for our determinations a content of hydrochloric acid in that region and added, for instance, to a solution of 0.4 grms. of rubber in 45 cc. benzene, after filtering through cotton wool, 1.5 cc. of a 0.15 Norm. solution of hydrochloric acid in benzene (strength determined by titration in a large quantity of water), or about 5 millimol per liter.

The use of benzene-hydrochloric acid has two disadvantages. First the hydrochloric acid evaporates rapidly and the solution decreases in strength even from the repeated opening and closing of the bottle for taking out a certain portion. It is therefore necessary to check the strength from time to time; when one takes care to keep the hydrochloric acid content sufficiently high, this change in the dose of hydrochloric acid is of no practical importance because the viscosity at different contents of hydrochloric acid is constant.

A second drawback is that hydrochloric acid has a markedly deteriorating influence on the rubber. Traces of this acid, which remain in the dry rubber after coagulation cause it to become tacky in a short time; EGGINK already pointed out that the benzene solution of rubber even after a short time showed a decrease in viscosity. It was found that in the circumstances under which we work decrease in viscosity is about 0.15 in five minutes. By making

¹⁾ Archief voor de Rubbercultuur 4 (1920), 124; Ind. Rubb. Journ. 59 (1923), 1197.

the determinations always in the same manner the error can be kept practically constant (the time between the addition of the hydrochloric acid and the first reading of the time of flow is about 3 to 4 minutes); we have not applied a correction for this decrease in viscosity in the preliminary experiments to be described in this paper.

Especially the latter point is a drawback of this method of determination. We therefore investigated whether with other acids better results might be obtained. Acetic acid easily dissolves in benzene, but was found to discharge the rubber only at a much larger concentration (about 0.4 normal) and to have not so sure an effect as hydrochloric acid.

We hope to continue the experiments with other acids, amongst others formic acid, but have restricted ourselves in this first investigation to benzol-hydrochloric acid.

It is interesting to draw attention to the fact that the highest concentrations of acid (0.075 Norm. HCl and 0.405 Norm. acetic acid) do not cause the slightest trace of flocculation or coagulation in the benzol solution. In a watery emulsion (latex) of 1 % rubber content coagulation takes place at an acidity of 0.002 Norm. both for hydrochloric and acetic acid ¹⁾. The difference caused by the small degree of solvation in water and the large degree of solvation in benzene is very apparent, bearing out the explanation given by KRUYT and VAN BUNGENBERG DE JONG ²⁾.

2. *Factors from group 1.*

As a first experiment we prepared, from portions of 100 cc. taken from one lot of well mixed latex, a series of samples which, according to the conclusions we had formulated, might be expected to show differences in viscosity due to factors from group 1 (coagulants, other chemicals, serum substances and their decomposition products). These experiments gave the results mentioned in table I; the amounts mentioned hold for 100 cc. of latex (undiluted or diluted).

The "ordinary" viscosity shows the differences that were to be expected. The normally prepared control sample (4656 B) was coagulated by 7 cc. of a 2½ % acetic acid solution and creped (as all other samples with the exception of 4656 E and F) about 2 hours after coagulation in the ordinary way. This sample shows a normal figure for viscosity of about 30.

¹⁾ Proc. Royal Acad. Amsterdam, Vol. XXVI, p. 675.

²⁾ Zeitschr. phys. Chem. 100 (1922), 250.

TABLE I.

Sample	Description	Viscosity	
		ordinary	acidified
4656 L	5 grm sodium acetate, 14 cc. 7½% acetic acid	36.3	16.3
" F	coagulated spontaneously creped after 1 week	34.5	15.9
" E	" " " " 1 day	32.7	16.3
" B	control, 7 cc. 2½% acetic acid	30.3	15.8
" P	as B, after crepeing 2 hours in water of 90°	23.9	15.8
" A	latex diluted 1:1, with 4 cc. 2½% acetic acid	29.0	15.9
" G	21 cc. 2½% acetic acid	29.0	15.6
" H	1 grm of alum	21.8	15.7
" K	latex diluted 1:1, 0.5 cc. 3.4 Norm. sulphuric acid	16.9	15.7

The highest viscosity was found in sample 4656 L from latex to which a large dose of sodium acetate had been added, and which of course needed a large dose of acetic acid for coagulation. Sodium acetate, as all alkaline substances, causes an increase in viscosity; this increase is not nullified by the effect of the double quantity of acetic acid. This, therefore, is an example of the addition of a chemical that gives an increase in viscosity.

The next two samples (4656 E and F) were coagulated spontaneously (without acetic acid) and left 1 and 7 days respectively before being rolled. A decomposition of serum substances then takes place, which gives an increase in viscosity. Compared with the control sample the above three samples show the normal differences in "ordinary" viscosity, but in acidified benzene the figures are practically equal.

When the freshly rolled crepe is kept for two hours in hot water, the viscosity decreases considerably (sample 4656 P). Up till now one was in doubt whether this was caused only by an extraction of serum substances (factor from group 1), or whether a change in the colloidal state of the rubber caused by the temperature of 90° (factor from group 1) had also been at work. The viscosity in acidified benzene clearly shows that the rubber itself is unchanged and that in this case there has only been an extraction of serum substances.

Another example of a decrease in the amount of serum substances is provided by sample 4656 A: the latex was diluted with an equal

volume of water and coagulated with 4 cc. of $2\frac{1}{2}\%$ acetic acid per 100 cc. of diluted latex. The "ordinary" viscosity decreases somewhat, as usual, but the viscosity in benzene-hydrochloric acid remains unchanged.

The last three samples show the influence of acids and acid chemicals. The use of three times the ordinary amount of acetic acid causes a small decrease in viscosity; an ample dose of alum, used as a coagulant, gives the usual low viscosity, whilst a very large dose of sulphuric acid (about ten times the minimum dose necessary for coagulation) gives a very low viscosity. Nevertheless the viscosity in acidified benzene is, in these three cases, unchanged!

Reviewing the figures in table I, the contrast between the largely decreasing figures in column I and the nearly equal figures in column II is very striking. Especially in the case of alum the result is interesting, because some investigators have supposed coagulation with alum to give an inferior rubber. It will be clear from table I that this is not the case; the rubber itself is unchanged.

We prepared a second series of samples to test further the influence of the content of serum substances, by strongly diluting the latex. The results are contained in the following table.

TABLE II.

Sample	Dilution	$2\frac{1}{2}\%$ acetic acid cc.	Rolled day	Viscosity	
				ordinary	acidified
4801 A	undiluted	7	same	41.9	19.5
" B	"	7	next	42.7	20.3
" C	"	4	"	43.7	20.3
" D	1 : 1	4	"	40.3	20.3
" E	1 : 4	2	"	38.5	19.2
" F	1 : 9	1.2	"	35.0	19.5
" G	1 : 19	0.6	"	35.5	19.0

The first sample is the control, prepared in the same way as in series 4656 but from another latex. Sample 4801 B was coagulated by the same amount of acetic acid, but rolled the next day; this gives a small increase in viscosity. Sample 4801 C was also rolled the next day but with a smaller amount of acetic acid (a sufficient dose when rolling 24 hours after coagulation) and therefore gives

a somewhat larger viscosity. The other samples show clearly a decrease in viscosity as the dilution of the latex increases and the rubber therefore retains less serum substances during coagulation.

The last column again shows very clearly that the viscosity in acidified benzene is practically the same for all samples. Whether the small differences from 20.3 to 19.0 have a certain significance or whether they must be ascribed to errors of determination can only be determined by a more extensive investigation.

The influence of traces of acid used for coagulation is very clearly seen from the following example.

TABLE III.

Sample	Coagulant	Viscosity	
		ordinary	acidified
4862 A	acetic acid, 5 cc.	32.3	16.6
" B	" 10 "	31.4	16.1
" C	" 20 "	29.8	16.0
" D	formic acid, 2 $\frac{1}{2}$ "	31.1	16.6
" E	" 5 "	30.0	16.5
" F	" 10 "	27.3	16.5
" G	oxalic acid, 4 "	30.8	16.6
" H	" 8 "	24.5	16.6
" I	" 12 "	19.9	15.3

The latex was diluted to 20% rubber content and coagulated by the above mentioned amount of 2 $\frac{1}{2}$ % acid per 100 cc. diluted latex.

An increase in the amount of acetic acid gives the usual small decrease in "ordinary" viscosity. Formic acid is a stronger coagulant and gives, in larger doses, a larger decrease in "ordinary" viscosity. The non-volatile oxalic acid gives a considerable decrease in "ordinary" viscosity. The figures for „acidified" viscosity are, however, the same for all samples, showing that the differences in "ordinary" viscosity are only caused by the traces of acid absorbed by the rubber.

3. *Factors from group 2.*

That factors from group 1 give a charge to the rubber can there-

fore be demonstrated very clearly by a comparison between the "ordinary" and the "acidified" viscosity. In order to investigate how the figures are affected when factors from group 2 play a role we made the following experiments.

Heating. Heating, provided no oxidation takes place, causes a disaggregation and weakening of the rubber without the quality really deteriorating and especially without the properties after vulcanisation suffering from it. Viscosity and swelling properties, however, change very much, and it was therefore to be expected that the viscosity in acidified benzene would decrease. This was indeed found to be the case.

TABLE IV.

Sample	Description	Viscosity	
		ordinary	acidified
4656 B	Control	30.3	15.8
" P	fresh crepe 2 hours in water of 90°	23.9	15.8
" M	fresh crepe dried in vacuo at about 80°	21.6	14.3
4801 A	Control	41.9	19.5
" I	fresh crepe dried 2 hours at 90°	35.0	19.5
" Q	dry crepe 2 hours at 90°	28.4	17.3

Soaking of the freshly rolled crepe in water at 90° (sample 4656 P) has already been discussed above; the viscosity decreases but the rubber itself remains unchanged, as may be seen from the viscosity in acidified benzene. Heating the freshly rolled, wet crepe for two hours in hot air at 90° causes a decrease in ordinary viscosity, but the viscosity in acidified benzene remains unchanged (sample 4801 I). The still moist crepe is, in agreement with other observations, relatively insensitive to heat.

When heating air dry crepe however, whether the fresh crepe is heated for some time in vacuo (sample 4656 M) till it is quite dry but also rather weak, or whether the air dry crepe is heated in a drying oven at 90° C. (sample 4801 Q), the viscosity in acidified benzene also decreases and the colloidal state of the rubber therefore changes.

There is no certainty, however, that in these causes one has exclusively to do with a change in the colloidal properties, because a slight degree of decomposition of serum substances is not excluded during drying; the colour of the rubber may darken markedly and the smell changes. Oxidation could only be excluded with certainty by repeating the experiment in a closed tube filled with an inert gas. The results obtained in these experiments would therefore have to be controlled. The fact that the properties after vulcanisation remain unchanged makes it probable that the rubber itself is not affected.

Plasticising. A second example of a factor belonging to group 2 and causing a decrease in viscosity without affecting the properties after vulcanisation, is plasticising or mastication. Its influence may be seen from the following experiment:

TABLE V.

Sample	Description	Viscosity	
		ordinary	acidified
4801 B	Control	42.7	20.3
" M	same, creped twice as long	39.0	18.9
" N	" , " four times as long	24.0	14.0
4801 F	Control (latex 1 : 9 dilution)	35.0	19.5
" O	same, creped twice as long	30.0	18.4
" P	" , " four times as long	17.5	13.0
4656 B	Control	30.3	15.8
" C	same, creped very long (10 minutes)	8.2	6.3
" Q	dry crepe slightly plasticised (5 times)	22.2	13.1
" R	" " plasticised longer (10 times)	2.7	2.2

When continuing the crepeing and washing of the coagulum on the rolls longer than usual the viscosity decreases. As the cause one might consider a further removal of serum substances; but as the rate of cure does not decrease or only to a small degree by this prolonged rolling, we have in former years sought the explanation in a beginning of plasticising. The decrease of viscosity in acidified

benzene shows that this explanation was correct. When crepeing for a very long time, so that the crepe becomes markedly sticky (sample 4656 C) the viscosity in acidified benzene even decreases very much.

When plasticising the dry crepe on hot rolls, as is done before mixing in the sulphur, the first five times of rolling, when rolls are still rather wide apart (sample 4656 Q), cause a distinct decrease in both viscosities; prolonged plasticising (sample 4656 R) causes both the ordinary and the acidified viscosity to decrease to a very low value.

4. Factors from group 3.

Different factors may affect the rubber so strongly that a real decay sets in and that the properties after vulcanisation also suffer, or even that a proper vulcanisate can no longer be obtained. One may, of course, expect that these factors would also cause a decided decrease in viscosity in acidified benzene.

As a first example we investigated the influence of sunlight by hanging a crepe prepared on September 26 for about three hours in the sun on September 27, 28 and 29, that is during the time the crepe was drying. The following figures were obtained:

TABLE VI.

Sample	Description	Tested	Viscosity	
			ordinary	acidified
4656 B	Control	—	30.3	15.8
4656 N	In the sun	8 October	10.3	6.1
	same, kept in the dark	26 "	9.3	6.0
	" " " " " "	10 December	9.2	6.4
	" " " " " "	10 January	8.6	6.3

The figures decrease very much by sunning; when keeping the rubber afterwards in a closed box the ordinary viscosity decreases still a little further, but the viscosity in acidified benzene remains constant.

A second example of deterioration is provided by the tackiness caused by oxidation when traces of a copper salt are present. The rubber at first becomes sticky and then gradually resinifies. We found the following figures:

TABLE VII.

Sample	Description	Tested	Viscosity	
			ordinary	acidified
4656 B	Control	—	30.3	15.8
4656 O	as B, 0.1 grm of CuSO_4 5 aq added to the latex	8 October	15.6	9.3
		27 "	9.0	6.7
		16 November	5.8	5.0
		6 December	3.4	3.5
		5 January	2.3	2.2
		5 February	1.6	1.5

Therefore not only a marked decrease during the time the crepe hung to dry (26 September—8 October) but also a further decrease when keeping the crepe between sheets of paper in a wooden box or cupboard, till at last the viscosity in ordinary benzene is equal to that in acidified benzene and one has no longer to do with rubber but with different resinous oxidation products.

Traces of hydrochloric acid also attack the rubber very severely and lead to tackiness and resinification. The viscosities were;

TABLE VIII.

Sample	Description	Tested	Viscosity	
			ordinary	acidified
4656 A	Control, prepared 26 September	—	29.0	15.6
4656 I	latex 1 : 1, 17½ cc. HCl 3.1 norm.	6 October	14.0	13.0
		19 "	13.3	11.9
		6 December	9.6	9.3
		5 January	7.6	7.6
		5 February	6.0	5.5

Both crepes were dried in the air in subdued daylight. The very large dose of hydrochloric acid used for coagulation (about 0.46 Normal on the latex, i.e. well into the second zone of coagulation) causes a decrease in ordinary viscosity to nearly the value of the acidified viscosity; in other words the traces of hydrochloric acid

retained by the dry rubber were sufficient to discharge it nearly completely in benzene. During the time the rubber hung to dry the viscosity in acidified benzene decreased from 15.6 to 13.3, and by further keeping in the dark it continued to decrease.

Rubber that contains traces of hydrochloric acid gets tacky in the light much quicker than in the dark. We collected the following figures:

TABLE IX.

Sample	Description	Tested	In dark		In light	
			ordinary	acidified	ordinary	acidified
4801 A	Control, prepared 14 Nov.	—	41.9	19.5	—	—
4801 R	Coagulated with 35 cc. HCl 3.1 Norm.	28 Nov.	18.4	18.0	—	—
		5 Dec.	18.1	18.3	14.8	14.6
		12 "	18.8	18.2	11.9	12.2
		19 "	18.0	19.0	12.1	11.6
		12 Jan.	17.2	17.3	6.4	5.5
		12 Febr.	17.2	15.9	3.0	2.0
4801 D	Control, latex, 1 : 1, prepared 14 November	—	40.3	20.3	—	—
4301 H	Latex 1 : 1, 17½ cc. HCl 3.1 Norm.	28 Nov.	17.7	17.1	—	—
		5 Dec.	18.1	16.5	13.9	14.7
		12 "	17.6	17.0	12.3	12.8
		19 "	18.8	16.6	11.4	9.9
		12 Jan.	17.2	16.4	4.5	3.0
		14 Febr.	17.0	18.2	4.0	3.6

The control samples were dried after coagulation in ordinary, subdued daylight, but the crepes coagulated by hydrochloric acid were hung to dry in a dark room. The viscosity, during the time of drying, decreased much less than in the former experiment (table VIII), but both viscosities had already decreased somewhat when the rubber was tested for the first time on November 28. From that date onwards half of the samples was enveloped in a piece of paper and kept in a well closed wooden box and only exposed to the light for a moment when sampling for the tests.

The other half was laid on a table, exposed to ordinary daylight and even sometimes, in the early morning, to direct sunlight. The figures in table IX each relate only to one determination, and are not averages of two or three determinations as is the case with the figures in all the other tables; the errors of determination play a clearly visible role and cause in one case the ordinary, in another case the acidified viscosity to show a slightly higher figure. The slow decrease in both viscosities when keeping in the dark, and rapid decrease when keeping in the light is nevertheless clearly seen from table IX.

Sample 4801 R, coagulated with the largest amount of hydrochloric acid, shows nearly the same value for both viscosities, indicating that the rubber in ordinary benzene was completely discharged by the traces of coagulant retained by it. Sample 4801 H shows nearly always a slightly higher figure for viscosity in ordinary benzene and was evidently not completely discharged.

5. *Other cases.*

Different factors in preparation have a complicated influence on the properties of the rubber. While in the cases discussed above an explanation could already be given on the basis of earlier experiment, and the factor causing a change in viscosity could be identified with a reasonable degree of certainty, so that the conclusions drawn in 1918 had only to be confirmed by the present investigation on the viscosity in acidified benzene, there are other cases in which an explanation could hitherto not be given. We tried to solve these points also by using the new method.

Coagulation by heating the latex, for instance, gives a rubber with a low viscosity, a large rate of cure and unchanged mechanical

TABLE X.

Sample	Description	Viscosity	
		ordinary	acidified
4656 B	Control	30.3	15.8
„ S	coagulated by heating	23.6	16.2
4801 A	Control	41.9	19.5
„ L	coagulated by heating	29.2	20.2

properties after vulcanisation. Generally a quicker rate of cure is accompanied by a larger viscosity; that the viscosity in this case shows a decrease might be explained by the effect of heating causing a decrease larger than the increase from the included vulcanisation-catalysts.

The decrease in "ordinary" viscosity is in both cases very marked, but the "acidified" viscosity shows no decrease and a factor from group 2 has therefore not been at work. The hypothesis put up in former years was therefore not the correct one, and it seems that we have to do, in this case, with some serum constituent that decreases viscosity but causes an increase in rate of cure.

Complicated are also the changes caused by coagulation with alcohol. One obtains a rubber with a higher ash content, a lower viscosity, a somewhat larger slope of the stress strain curve (that is a somewhat weaker vulcanisate), an unchanged tensile strenght and rate of cure. An explanation for this combination of properties could not yet be given. We found:

TABLE XI.

Sample	Description	Viscosity	
		ordinary	acidified
4656 B	Control	30.3	15.6
" T	Coagulated with $\frac{1}{2}$ vol. alcohol	23.0	13.9
4801 A	Control	41.9	19.5
" K	Coagulated with $\frac{1}{2}$ vol. alcohol	34.7	19.3
4979 A	Control	29.1	15.6
" K	Coagulated with $\frac{1}{2}$ vol. alcohol	21.8	14.2
" L	" " 1 vol. "	21.7	14.5

The "ordinary" viscosity has therefore decreased markedly in all three experiments by the coagulation with alcohol; the viscosity in acidified benzene decreased somewhat in two out of the three cases. The lower value for the "ordinary" viscosity is therefore only partly to be ascribed to a higher content of electrolytes, and is partly caused by a (not yet further explained) change in the rubber itself.

Rubber from matured coagulum (coagulum that is kept for some

time in the wet state, resulting in a decomposition of serum substances by micro-organisms, had formation of vulcanisation accelerators) often shows a very high viscosity and a somewhat higher tensile strength than ordinary plantation rubber. Some investigators hold the opinion that the inner properties of such rubber are better; we have ascribed the higher tensile strength to the fact that such rubber vulcanises very quickly and therefore is exposed for a shorter time to the deteriorating influence of the high temperature of vulcanisation.

When determining the viscosity of such rubber in acidified benzene one finds normal figures. For instance:

TABLE XII.

Sample	Viscosity	
	ordinary	acidified
4329 AW	53	16.8
" BW	75	17.6
4766 AW	65	21.7
" BW	67 $\frac{1}{2}$	19.4
" CW	58	20.1
" DW	53	19.3

Control samples of ordinary crepe, prepared from the same latex, were not available, but it may be clearly seen that the high values for ordinary viscosity completely disappear when acidifying the benzene; the figures for acidified viscosity are the same as found for ordinary samples of rubber, so that the high figures may be ascribed to a change caused by the (alkaline?) decomposition products of serum constituents (proteins?).

Rubber from young trees shows strongly deviating properties, namely a low tensile strength and viscosity, a high figure for slope and a quick rate of cure. That the quality of such rubber is inferior may be ascertained by pulling the sheets by hand; the rubber is brittle or "short", breaks more easily than ordinary plantation rubber.

The viscosity was found to be: (See table XIII)

The ordinary viscosity is therefore low, but the viscosity in acidified benzene is still considerably lower, so that from these figures also it is clear that in such cases the rubber itself is inferior.

TABLE XIII.

Sample	Viscosity	
	ordinary	acidified
3985 A	7.0	4.4
„ Bw	6.4	4.4
4965	17.7	10.1
5121 A—D	20.7	12.0
4959	24.6	13.1

We intend to continue these investigations extending them to a number of other cases, and to compare the results with other properties, such as plasticity, which (according to preliminary determinations) seems to show a certain parallism with the viscosity in acidified benzene.

6. Conclusion.

From the foregoing it will be clear that a determination of the viscosity in acidified benzene, besides the viscosity in ordinary benzene, promises to become a valuable acquisition in the study of the factors that influence the properties of rubber.

Whether this determination may become of importance for the ordinary testing of rubber will have to be investigated further. In that case one very often has to do with first quality product, in which the properties of the rubber itself are mostly good, but in which the content of by-substances (traces of chemicals, serum constituents etc.) may vary according to the method of preparation and may give an undesirable variability in rate of cure. In such testing work the ordinary viscosity will give valuable indications, but the viscosity in acidified benzene will not show large differences.

When, however, one has to do with the lower grades of rubber (for instance the brown types), important information may be expected from the viscosity determined in acidified benzene, which will allow a more reliable conclusion as to the quality of the rubber than the viscosity in ordinary benzene.

When testing special types of rubber, prepared by other methods than those for the ordinary plantation product, the viscosity in acidified benzene will doubtless prove a very valuable asset.

Buitenzorg, February 1924.

Central Rubberstation.