Production of Tannin from the Bark of *Eucalyptus camadulensis*

K. R. Onifade
Department of Chemical Engineering
Federal University of Technology, Minna, Nigeria

Abstract

Tannin is a very versatile industrial material found in many parts of plants such as the bark of Eucalyptus camadulensis *(EC). The bark of EC that normally peels off during the dry season has usually served as anxious substrate for pathogens.*

In the present experiment, tannin was leached from the bark of EC using water as solvent. Tannin produced varied from 5 to 12%. The yield obtained was found to vary inversely with the particle size of the bark. Better yields were obtained if distilled water and agitation method were used in comparison with tap water and soaking method. However, the increase in yield was not statistically significant. Method of solvent removal and doubling the amount of solvent used has little or no effect on yield.

Keywords: *Tannin, bark,* Eucalyptus camadulensis, *distilled water, tap water.*

Introduction

Eucalyptus is a large genus of mostly large trees of the Family Myrtaceae (Order Myrtales) which is native to Australia, New Zealand and Tasmania. There are about 600 species based largely on their bark characteristics. The bark is either smooth or rough with varying degrees in each class. *Eucalyptus camadulensis* (EC) is one of the most common eucalypti (Anon. 1973; Anon. 1979; Anon. 1989).

*E*C, also called "river red gum", was the first species introduced to Nigeria in 1916. Since then it has adapted and thrived well because its plantation requires non-expensive inputs for propagation. There is a large plantation in Afaka, Kaduna State. Nigeria has also recorded the best yield of eucalyptus trees in Africa (Jamieson 1967; Keay 1989).

Eucalyptus trees are essentially utilized as fuels, as timber in construction and poles for electricity and telecommunication transmission line (Anon. 1979; Anon. 1994). These primary uses have made them important component of third world economies. They have also been exploited commercially for apiculture; production of wood and essential oils; for making ornamentals (due to their colorful flowers); and incorporated into inhalants (Anon. 1979; Evans 1989).

Tannin is a general term for a widely occurring group of substances of vegetable origins which occur in oak gallnuts, tea and barks of 'Suma' oak mangrove (Fahn 1982). It also occurs in some of the eucalyptus trees such as *EC* (Esau 1965). It is a light to brown amorphous granular powder with the chemical formula $C_{76}H_{52}O_{10}$, which decomposes at 210-215°C. There are two types of tannin, namely, the condensable and the hydrolyzable (Godwin and Mercier 1983). In the former, the benzene nuclei are joined to the larger complex by carbon linkages, while in the latter, they are joined by oxygen atoms.

Condensable tannins are largely polymeric condensation products of catechin or catechin- like substances. They cannot be hydrolyzed by acids or enzymes, but condense readily to lower molecular-weight tannins.

Hydrolyzable tannins decompose in water, with which they react to form other useful substances such as garlic acid, pyrotocatechi acid

pulp; oxalic acid (Onifade 1990; Onifade 1997) and sugar. Gallotannin, the best-known hydrolyzable tannin, is extracted by treating Turkish or Chinese nutgall with water or organic solvents.

Tannins have diverse uses (Austin 1994). The traditional use is for rendering raw hides into leather. But they have also been employed industrially in denaturing alcohol; in aqueous solution for treating burns and protecting plant against dehydration and damage by animals; as mordants on dyeing; as antidote for metallic, alkaloid and glycoside poisons; and as reagents in photography. They are also added to mud in oil drilling operation to increase the viscosity and have been used for the manufacture of ink, rubber and plastics; for preventing sculling in hot waters; for ores flotation and water treatment; and by combining them with binding agents such as polyvinyl pyrrolidone (PVP) to clarify wine and beer.

Due to the dangers posed by the environment from wastes in various forms, there has been a new research focus in the effective utilization of chemical and agricultural by-products that have hitherto been regarded as wastes. It is also a step in the right direction of a new initiative called "ZERI option" which discusses the use of waste or pollutants from one system as raw materials in another system (Agho 1999). The bark of EC normally peels off during the dry season and litter the plantation, serving as ready substrate for pathogens.

The objective of this work is to explore the possibility of a commercial production of tannin from the bark of EC.

Experimental Work

The bark of EC was dried, ground and classified into different sizes using a sieve shaker. An amount of 0.5 kg of the ground bark was taken from each size range and put in a beaker. Tap or distilled water was added and the mixture agitated or soaked for a period of time. The resulting solution was filtered and tannin was recovered as flakes from the filtrate by distilling off the solvent or evaporating it in an open beaker. The temperature of the heating medium was adjusted when the tannin started forming as flakes. The tannin content of the extracts was compared by using a colorimeter to measure the absorption factor (at wavelength of 540 nm) of a prepared solution of the extract to which ferric chloride was added.

Table 1 gives the experimental data for the operating variables. It shows that the variables investigated were particle size distribution, leaching time, type of solvent, method of leaching and method of solvent removal.

Results and Discussion

Tables 2 to 4 show the yield and yield percent for the different experimental runs. The yields for smaller-sized samples were greater than those of larger-sized samples. This is in consonance with mass transfer theory because the former present higher interfacial area between the solvent and solute. The solution of tannin produced has pH of 6.0. It is therefore acidic as expected.

Table 2 and 3 were obtained using the same operating parameters, except for the leaching solvent. Tap water was used for the set of experiments in Table 2 while distilled water used for that in Table 3. From Fig.1, it can be clearly seen that the yields obtained for 1 hr were bigger in Table 2 than in Table 3. The same holds for other leaching times. The absorption factors of the extracts in EXPTA were higher than those of EXPTB. A typical value of the absorption factors is shown in Table 6. Since tap water was used in EXPTA, this implies that tannin may have contained higher impurities that the tannin of EXPTB. However, when the statistical comparison of the results for EXPTA and EXPTB (typified by EXPTA1 and EXPTB1) is done as in Table 7, it could be seen that the difference in yield is not appreciable because the correlation coefficient is close to 1.0.

Fig. 2 compares the yield of EXPTA for 3 hours with that of EXPTC for 6 hrs. It was expected that the yield for 6 hrs should be considerably higher. This was not so except for sample size range 250-500 (x 10^{-6} m). Agitation was employed in EXPTA while soaking was used in EXPTC. Since agitation increases the rate of mass transfer of material from the surface of the solute to the bulk of the solution, the only plausible reason for the small difference in yield could be attributed to the method of leaching. The effect is even more discernible in the sample size above 850 x 10^{-6}m where the yields for 3 hrs were even higher than that for 6 hrs. The statistical comparison of EXPTA3 and EXPTC1 in Table 7 shows that the difference in yield is not very appreciable as the correlation coefficient is close to 1.0.

The effect of volume of solvent can be seen from Fig. 3 where the tannin yields for EXPTC1 and EXPTD1 were compared. It can be seen that there was not much difference in yields showing that the effect of volume is not very appreciable. This is also confirmed by the statistical analysis of results of EXPTC1 and EXPTD1 in Table 7 where the correlation coefficient is close to 1.0.

Conclusion

Tannin has been confirmed to be present in EC bark and a yield of between 5 and 12% was obtained. If the large plantation of EC (where it is cultivated) is taken into account, the amount of tannin that can be produced is substantial. The effect which operating parameters have on yield of tannin was discussed. It shows that further investigation may be necessary to optimize the operating parameters for profitable design of a plant to exploit the production of tannin from the bark of EC.

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Table 1. Experimental data for the operating variables.

	Leaching time (hrs)	Solvent	Volume of solvent (x 10^{-6} m^3)	Leaching method	Method of solvent removal
EXPTA1	1	Tap water	1000	Agitation	Distillation
EXPTA2	2	Tap water	1000	Agitation	Distillation
EXPTA3	3	Tap water	1000	Agitation	Distillation
EXPTB1	1	Distilled water	1000	Agitation	Distillation
EXPTB2	2	Distilled water	1000	Agitation	Distillation
EXPTB3	3	Distilled water	1000	Agitation	Distillation
EXPTC1	6	Tap water	1000	Soaking	Distillation
EXPTC2	12	Tap water	1000	Soaking	Distillation
EXPTC3	24	Tap water	1000	Soaking	Distillation
EXPTD1	6	Tap water	2000	Soaking	evaporation
EXPTD2	12	Tap water	2000	Soaking	evaporation
EXPTD3	24	Tap water	2000	Soaking	evaporation

Table 2. Yield and percentage of tannin for EXPTA.

	EXPTA1		EXPTA2		EXPTA3	
Sample Size (x 10^{-6} m)	Yield (x 10^{-3} kg)	% Yield	Yield (x 10^{-3} kg)	% Yield	Yield (x 10^{-3} kg)	% Yield
250 – 500	3.80	7.6	3.88	7.8	3.87	7.7
500 – 710	3.72	7.4	3.72	7.4	3.85	7.7
710 – 850	3.66	7.3	3.69	7.4	3.71	7.4
850 – 1000	3.61	7.1	3.63	7.3	3.67	7.3
> 1000	3.57	7.1	3.57	7.1	3.59	7.2

Table 3. Yield and percentage of tannin for EXPTB.

	EXPTB1		EXPTB2		EXPTB3	
Sample Size (x 10^{-6} m)	Yield (x 10^{-3} kg)	% Yield	Yield (x 10^{-3} kg)	% Yield	Yield (x 10^{-3} kg)	% Yield
250 – 500	2.97	5.9	3.20	6.4	3.50	7.0

500 – 710	2.65	5.3	2.81	5.6	2.94	5.9
710 – 850	2.50	5.0	2.73	5.5	2.80	5.6
850 – 1000	2.23	4.5	2.38	4.8	2.59	5.2
> 1000	2.01	4.0	2.20	4.4	2.41	4.8

Table 4. Yield and percentage of tannin for EXPTC.

	EXPTC1		EXPTC2		EXPTC3	
Sample Size ($x 10^{-6}$ m)	Yield ($x 10^{-3}$ kg)	% Yield	Yield ($x 10^{-3}$ kg)	% Yield	Yield ($x 10^{-3}$ kg)	% Yield
250 – 500	4.59	9.2	4.99	10.0	5.69	11.4
500 – 710	3.89	7..8	4.89	9.8	5.31	10.6
710 – 850	3.74	7.5	4.90	9.8	5.05	10.1
850 – 1000	3.04	6.1	3.60	7.2	4.99	10.0
> 1000	1.90	3.8	3.57	7.1	4.15	8.3

Table 5. Yield and percentage of tannin for EXPTD.

	EXPTD1		EXPTD2		EXPTD3	
Sample Size ($x 10^{-6}$ m)	Yield ($x 10^{-3}$ kg)	% Yield	Yield ($x 10^{-3}$ kg)	% Yield	Yield ($x 10^{-3}$ kg)	% Yield
250 – 500	5.81	11.6	5.88	11.7	6.10	12.2
500 – 710	4.82	9.6	5.32	10.6	5.44	10.9
710 – 850	4.62	9.2	5.11	10.2	5.27	10.5
850 – 1000	4.59	9.2	5.03	10.1	5.00	10.0
> 1000	3.46	6.9	3.87	7.7	3.95	7.9

Table 6. Absorption factors for EXPTA1 and EXPTB1.

	Absorption factor	
Particle size ($x 10^{-6}$ m)	EXPTA1	EXPTB1
250 - 500	3.29	2.95
500 - 710	3.27	2.91
710 - 850	3.25	2.86
850 - 1000	3.23	2.82
> 1000	3.21	2.76

Table 7. Statistical comparison of yields.

Experimental runs compared	Correlation coefficient
EXPTA1 and EXPTB1	0.99
EXPTA1 and EXPTC1	0.93
EXPTC1 and EXPTD1	0.96

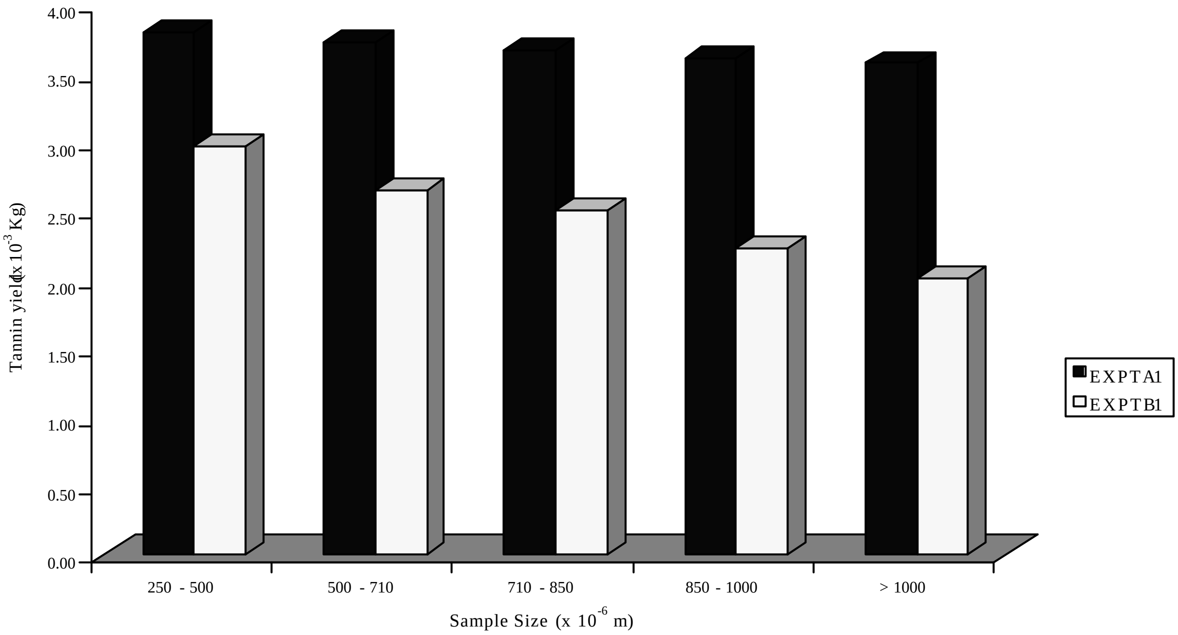

Fig. 1. Comparison of tannin yields for EXPTA 1 and EXPTB 1

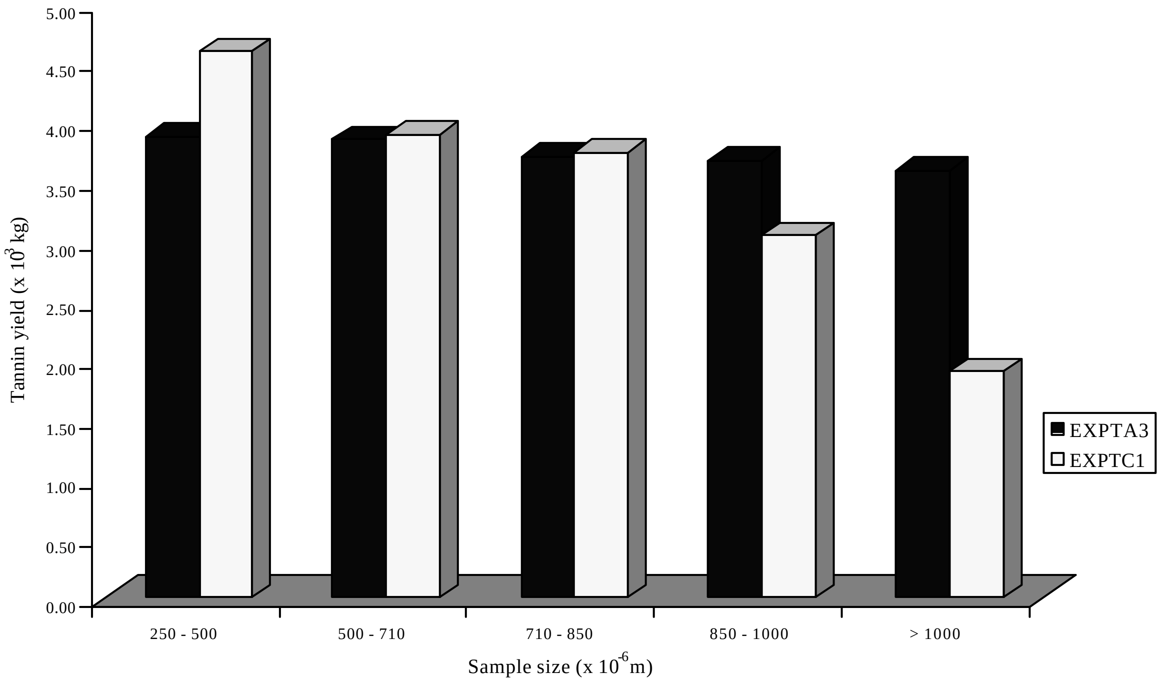

Fig. 2. Comparison of tannin yields for EXPTA3 and EXPTC1

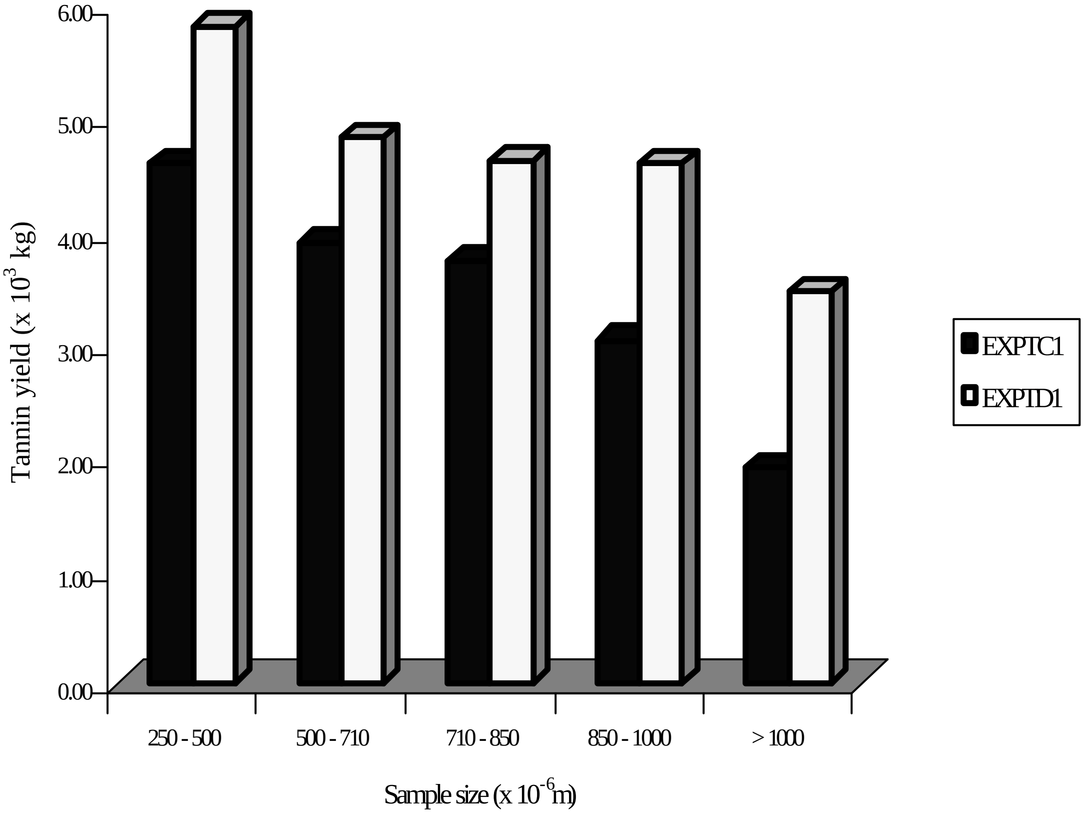

Fig. 3. Comparison of tannin yields for EXPTC1 and EXPTD1