

The Sorption of Tea Polyphenols on Nylon Fibers

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1. INTRODUCTION

Recently there has been growing interest in the use of natural dyes and extracts in textile applications. The tea extract containing tea polyphenols (TP) as the fundamental element, had been applied to the dyeing and functional finishing of textiles in virtue of its sanitarian properties [1-7]. However, little research has been done on the sorption of TP on nylon fibers. In this work, the research on the sorption of TP on nylon was emphasized, and the important factors affecting sorption were analyzed. These investigations were of great significance for TP application.

2. EXPERIMENTAL

The scoured, woven nylon fabric (210T) was obtained from Wujiang Zhiyuan Textiles Co. Ltd, China. A commercial tea polyphenol product of TP98 was purchased from Anhui She County Tea Alkaloid Factory, China; the contents of total tea polyphenols, total catechins and (-)-epigallocatechin gallate (EGCG) were 98%, 75% and 45%, respectively.

All experiments of TP sorption were carried out in partially sealed and conical flasks immersed in an universal dyeing machine using a 50:1 liquor ratio. The Britton-Robinson buffers (H_3PO_4 -HAc- H_3BO_3 /NaOH) were added to adjust pH.

The content of TP in solution was determined with the ferrous tartrate colourimetry method (GB/T 8313-2002). The absorbance of TP/ferrous tartrate complex solution at 540 nm was measured using a Shimadzu 1800 UV/vis spectrophotometer. The exhaustion of TP was determined according to the difference in the absorbance of the initial and final concentration of TP in solution. The quantity of TP on nylon was calculated by the initial quantity of TP in solution, the exhaustion and the weight of dried nylon.

3. RESULTS AND DISCUSSION

3.1. Effect of pH and temperature on TP stability and sorption

From Fig.1, it is evident that the absorbance of

TP solution at 273 nm became higher with increasing pH, but kept nearly constant at pH 4-5, indicating that TP solution had good stability in acidic buffer but comparatively poor stability in alkaline medium due to the ionization of phenolic hydroxyl groups and the alkali oxidation of galloyl groups. The palely yellowish color of nylon treated at neutral and alkaline medium also verified the poor stability of TP at related conditions. Fig.2 shows that the extent of TP sorption almost keep constant at pH 4-6, and decreased dramatically with increasing pH in the range of pH 7-9 due to the poor stability of TP in alkaline medium.

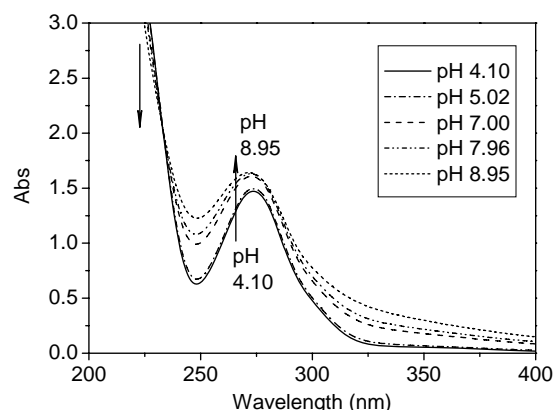


Fig.1. Effect of pH on the stability of TP solution.

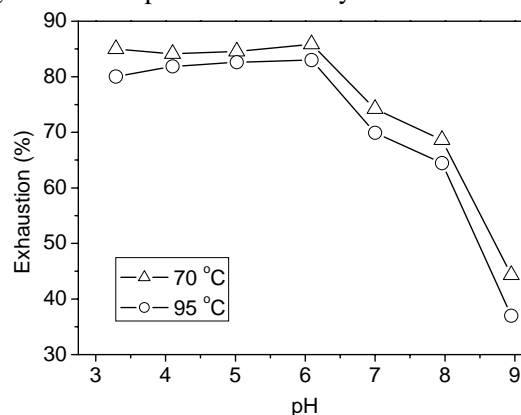


Fig.2. Effect of pH on the uptake of TP by nylon (TP 5% omf, 60 min).

Fig.3 shows that the exhaustion of TP was the highest at 60°C at two pH values and decreased

slightly at higher temperature. After TP blank solution was treated under different temperature at pH 5, the slightly little changes in the UV spectra and the absorbance at 273nm occurred, indicating that TP had the good stability at weakly acidic conditions in spite of application temperature.

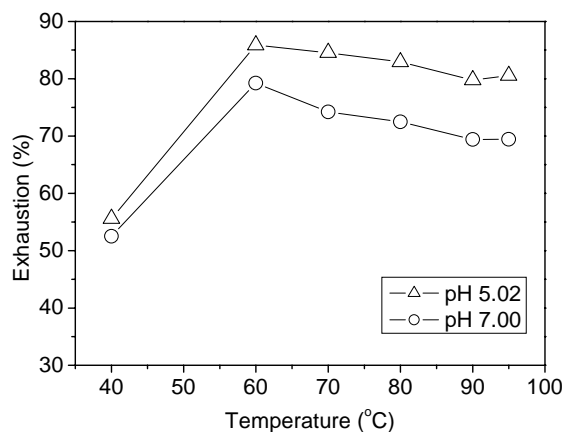


Fig.3. Effect of temperature on the uptake of TP by nylon (TP 5% omf, 60 min).

3.2. Sorption isotherms of TP on nylon

The sorption isotherms determined on the basis of the sorption for 4 h are given in Fig.4. The isotherms were fitted using a proposed dual sorption mechanism consisting of partition and Langmuir type models and the sorption parameters were listed in Table 1. All of the experimental points exactly superposed with the fitted curves, suggesting the validity of the proposed sorption mechanism. Therefore it may be concluded that under acidic conditions, the TP sorption occurs due to the electrostatic interactions between the ionized phenolic hydroxyl groups in TP and the protonated amino groups in nylon by Langmuir mechanism, and by virtue of hydrogen bonding between the uncharged phenolic hydroxyl groups in TP and the amino groups and amide groups in nylon as well as hydrophobic interaction between the non-polar moieties in TP and nylon by partitioning mechanism.

As shown in Table 1, the sorption parameters of TP sorption on nylon at various temperatures showed much variation. The Langmuir saturation value (S) decreased with increasing temperature, which could be induced by the higher extent of the ionization of phenolic hydroxyl groups in TP at high temperature. The Langmuir affinity constant (K_L) and partition coefficients (K_P) displayed a tendency to increase with increasing temperature, indicating that the heat effect of TP sorption towards nylon is endothermic.

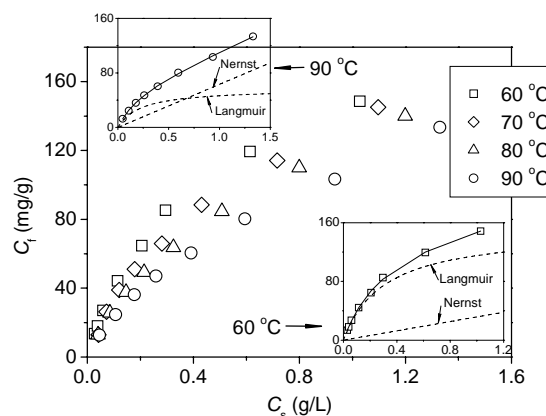


Fig.4. Sorption isotherm of TP on nylon at pH 4.1.

Table 1 Sorption parameters of TP sorption on nylon.

Temperature (°C)	Langmuir		Nernst
	K_L ($10^{-3}L/mg$)	S (mg/g)	K_P ($10^{-3}L/g$)
60	3.26	150.57	31.65
70	3.61	102.11	57.75
80	3.97	77.99	63.22
90	4.41	57.06	63.23

4. CONCLUSION

TP exhibited good stability in weakly acidic medium and high exhaustion at pH 4-6 at 60°C. The sorption isotherms of TP on nylon fitted a dual sorption mechanism consisting of partition and Langmuir type models.

5. REFERENCES

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