

REMOVAL OF *CANDIDA ALBICANS* FROM WATER BY ADHESION TO AMINOPHOSPHOROUS GROUPS GRAFTED ONTO POLY(STYRENE-CO-DIVINYLBENZENE)

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### Abstract

*Candida albicans* is a fungal pathogen capable of causing opportunistic infections that may be lethal. The purpose of this study was to establish the removal percent of a *Candida albicans* culture from a water solution by using some polymers with antimicrobial activity. The mechanism of action is based on yeast adhesion on aminophosphorous active groups.

### Introduction

*Candida albicans* is considered a dimorphic fungus. *Candida albicans* is a natural inhabitant of the upper respiratory, alimentary and genital tracts in healthy humans and animals. Fungal infections with this specie are frequent because it can cause opportunistic infections in hosts who are compromised by underlying local or systemic pathological processes.

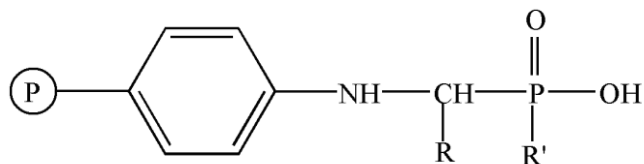
In United State, infection with *Candida albicans* is considered to be the fourth cause of disease on the bloodstream and the mortality rate exceeds that of bacteremia [2, 9].

In many countries, the intra-hospital infections with *Candida albicans* have reported as association of these microorganisms with the formation of biofilms on implantable medical devices [1, 4]. These devices support biofilm formation and *Candida albicans* have the property to form biofilm, so they are responsible for a considerable percentage of clinical candidiasis cases [1, 3, 4].

The purpose of this study was to establish the removal percent of a *Candida albicans* culture from a water solution by using some polymers with antimicrobial activity. The mechanism of action is based on yeast adhesion on aminophosphorous active groups.

### Experimental Part

Aminophosphorous groups grafted onto styrene–6.7% divinylbenzene copolymers are presented in Scheme 1.



Scheme 1. Aminophosphorous groups grafted onto poly(styrene-co-divinylbenzene); where: 3BA (R=benzyl, R'=phenyl; 4BA (R=propyl, R'= phenyl)

Aminophosphorous groups grafted onto styrene–6.7% divinylbenzene copolymers were obtained by “one-pot” reaction with copolymer grafted with amino group, phenylphosphinic

acid, benzaldehyde (or propionaldehyde) in tetrahydrofuran. The reaction was maintained under stirring for 24 h at 55°C. After cooling, the polymer was separated by filtration, washed with methanol, acetone and diethyl ether and dried at 50°C for 24 hours.

### Study of the removal of the *Candida albicans* from water

The experiment was carried out in a batch system with magnetical stirring. A quantity of each sample (3BA and 4BA) was introduced to 29 ml of sterile water. The concentration of reactive groups was 1 mmoles in every experiment. Into thus prepared mixture, 1 mL of microbial culture of *C. albicans* containing  $10^7$  CFU/mL was added in turn, and each mixture was stirred continuously (at room temperature) for 18 hours. At intervals of one hour, 3 hours, 6, 9 and 18 hours the number of bacterial cells of each system was determined. Then the number of colonies that grew on the Petri dishes was counted. The number of colonies/mL was established as an average value for the two plates by standard procedures [6, 7, 8].

### Results and discussions

The Fourier transform infrared spectra of the functionalized copolymer were obtained in KBr pellets on a Jasco FT-IR spectrophotometer (see Figure 1).

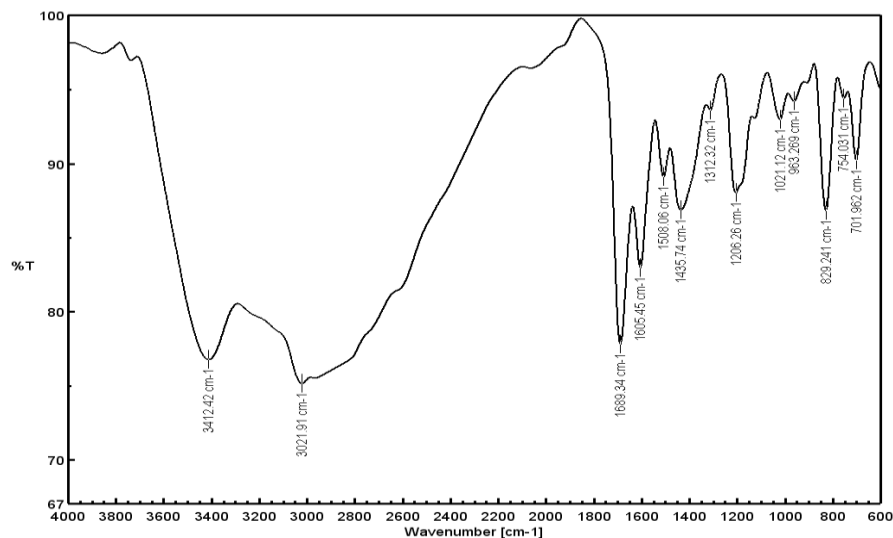


Figure 1. FTIR spectra of 3BA sample.

The bands from  $1206\text{ cm}^{-1}$  and  $1021\text{ cm}^{-1}$ , from the spectrum were assigned to group P=O and P-OH, they shows that reactions occurred with the formation of aminophosphorus groups grafted on copolymer.

In Figure 2 can be concluded that the copolymer 3BA and 4BA shows a very limited effect on yeasts.



Figure 2. Removal of the microbial culture of *C. albicans* with aminophosphorous groups grafted onto poly(styrene-co-divinylbenzene).

The ability of aminophosphorous polymeric materials for the removal of *Candida albicans* from waste water was studied using the removal coefficient [5].

$$R_{coef} = V / W_t \times \log[N(0) / N(t)]$$

Rcoef is Removal coefficient where are : N(0) is the initial viable cell count, N(t) is the viable cell count at contact time t, V is the volume of viable cell suspension, W is the dry weight of aminophosphorous polymeric materials, and t is the contact time.

Table 1. The Viable cell count at contact time t (h)

<b>N(t) for 3BA</b>					
0	1	3	6	9	18
213285	62540	60146	55500	53961	53285
<b>N(t) for 4BA</b>					
213285	80535	74568	63271	61245	58256

Table 2. Removal coefficient of *Candida albicans* at different intervals of time (hours) for 3BA sample.

<b>Candida albicans</b>	Removal coefficient of at different intervals of time (hours)					
	0	1	3	6	9	18
Removal coefficient	<b>0</b>	<b>10.25</b>	<b>15.98</b>	<b>17.01</b>	<b>17.38</b>	<b>17.54</b>

Where: V = 30 mL; W<sub>t</sub> = 1.03 grams; N(0) = 2.13·10<sup>5</sup>.

Table 3. Removal coefficient of *Candida albicans* at different intervals of time (hours) for 4BA sample

<b>Candida albicans</b>	Removal coefficient of at different intervals of time (hours)					
	0	1	3	6	9	18
Removal coefficient	<b>0</b>	<b>11.32</b>	<b>12.22</b>	<b>14.13</b>	<b>14.51</b>	<b>15.09</b>

Where: V = 30 mL; W<sub>t</sub> = 1.12 grams; N(0) = 2.13·10<sup>5</sup>.

This relation can be seen in Figures 3.

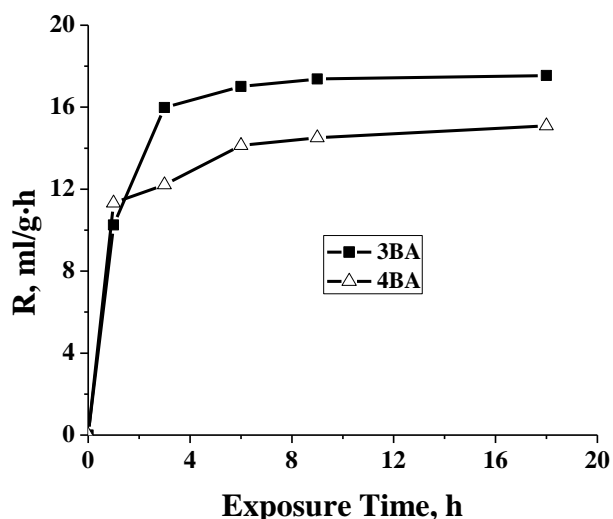


Figure 3. Removal coefficient of *Candida albicans* using 3BA and 4BA copolymer sample.

The antimicrobial activity was evaluated by the removal coefficient,  $R_{\text{coef}}$ , of the microbial culture. The results are showed in Figure 3. The copolymer 3BA had a better antimicrobial activity than the copolymer 4BA for the removal of the microbial culture of *C. albicans*. The antimicrobial activity is obtained at the interaction aminophosphorous active groups with the cell wall of *C. albicans*; so is explained the ability of the removal of the culture of *C. albicans*.

### Conclusions

The copolymers with aminophosphorous active groups were characterized by FTIR and they are considered that present antimicrobial activity. Batch treatment was used in the study of the removal of the *Candida albicans* from water. The copolymer 3BA had a better antimicrobial activity than the copolymer 4BA for the removal of the microbial culture of *C. albicans*.

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