

1,2 . . \*, 1,2 . . , 1,2 . . , 1 . . , 2 . . .  
1 - . . .  
2 . . .

\*mukhamed\_hav@ispm.ru

100 °C

0,05 0,21.

### SOLID-STATE MODIFICATION OF CHITOSAN BY CINNAMIC ACID

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**Abstract.** Solvent-free acylation of chitosan with cinnamic acid was performed under shear stresses in a twin-screw extruder. At 100 °C, varying the chitosan-to-cinnamic acid molar ratio (1:0.5, 1:1, 1:1.5) yielded derivatives with degree of substitution values ranging from 0.05 to 0.21. Fourier-transform infrared spectroscopy revealed that the solid-state reaction proceeds via two pathways, involving both ionic and covalent bonding of the acid or its residues to the amino groups of the polymer.

**Keywords:** solid-state synthesis, pressure and shear stresses, mechanical activation, chitosan, cinnamic acid

[1, 2]

95

( , . )

( ),

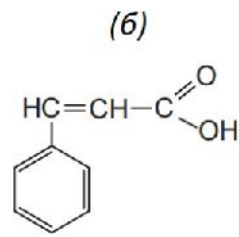
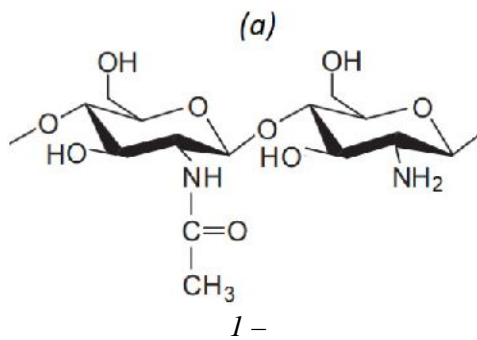
:

( , )

90 %,

( )

1.



( ) ( )

( / 1/0,5; 1/1 1/1,5)

100 ° .

3-5 , - 3.

48 .

1 %- 24 2 %-

9000 / 30

NaOH ( 1 / ),

pH, ( ), pH, (N) (H)

FLASH-2000 (Thermo Fisher Scientific, ).

C/N ( )

( ) Vertex 70 (Bruker, ).

2 4 <sup>-1</sup> Gladi ATR (Pike Technologies, ), (n = 2,4; 45°).

Bruker Opus ( 6.1).

1075 <sup>-1</sup> [3].

2 %- 92 %, 72-87 % ( 1).

1 - 2 %-

	2 %- 3 , %
	92
- 1:0,5	87
- 1:1	83
- 1:1,5	72

2 –

	%C	%H	%N	C/N	
	43,62 ± 0,12	6,67 ± 0,12	7,93 ± 0,02	6,42	–
- 1:0,5 <sub>p.</sub> *	42,73 ± 0,05	6,55 ± 0,10	7,21 ± 0,08	6,91	0,05
- 1:0,5 <sub>p.</sub> **	42,31 ± 0,01	6,47 ± 0,02	6,68 ± 0,01	7,39	0,11
- 1:1 <sub>p.</sub>	41,95 ± 0,04	6,68 ± 0,02	6,42 ± 0,02	7,62	0,13
- 1:1	42,25 ± 0,03	6,73 ± 0,10	6,10 ± 0,03	8,08	0,18
- 1:1,5 <sub>p.</sub>	42,18 ± 0,02	6,88 ± 0,04	6,33 ± 0,02	7,77	0,15
- 1:1,5	43,55 ± 0,01	7,02 ± 0,03	6,14 ± 0,01	8,27	0,21

\* . . – 2 %- 3 ; \*\* . . – 2 %-

3

2

[4]. 3

( )

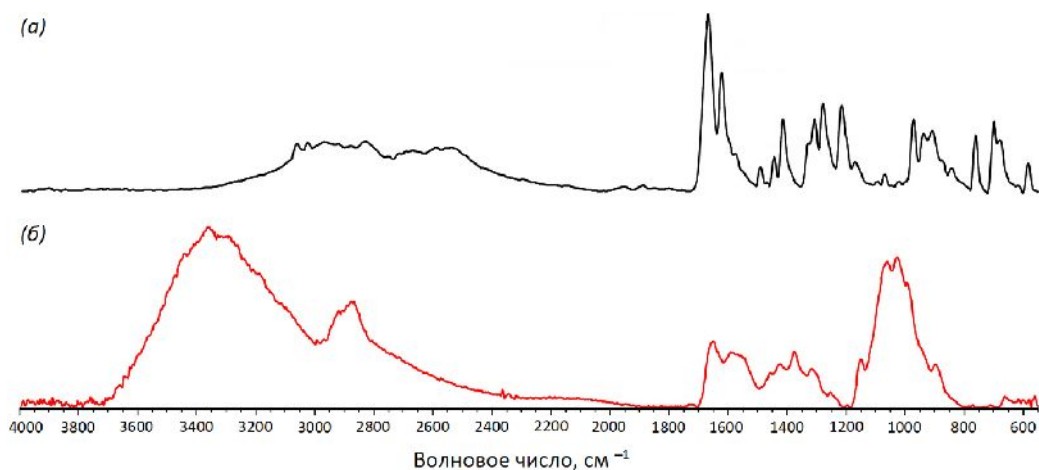
3 –

	( )	2 %- CH <sub>3</sub> COOH,
	–	555
- 1:0,5 <sub>p.</sub>	0,05	685
- 1:1 <sub>p.</sub>	0,13	735
- 1:1,5 <sub>p.</sub>	0,15	802

(685–802 )

2

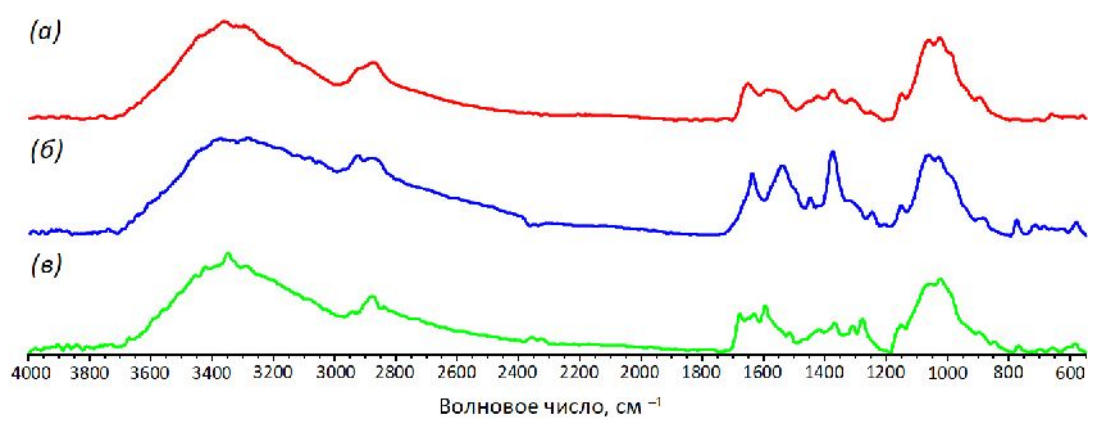
(555 )



2 – - : ( ) ( )

( 2 )  
 ( = ) ( =C)  
 1576, 1494 1449 <sup>-1</sup>,  
 ; 700-1000 <sup>-1</sup> C-H  
 2300-3400 <sup>-1</sup>  
 O-H C-H.  
 ( 2 3 ) (3700-2500 <sup>-1</sup>)  
 -O- , -C- ( NH<sub>2</sub>-  
 2871 <sup>-1</sup>), 3361 3294 <sup>-1</sup>

(1075 <sup>-1</sup>); C-O- (1150 <sup>-1</sup>);  
 CH, CH, NH, CH<sub>2</sub> (1320-1390 <sup>-1</sup>);  
 ( I) 1640 <sup>-1</sup>, 1561 <sup>-1</sup> ( 1560-1600 <sup>-1</sup>  
 II 1555 <sup>-1</sup>) 1320 <sup>-1</sup> ( III) [7].



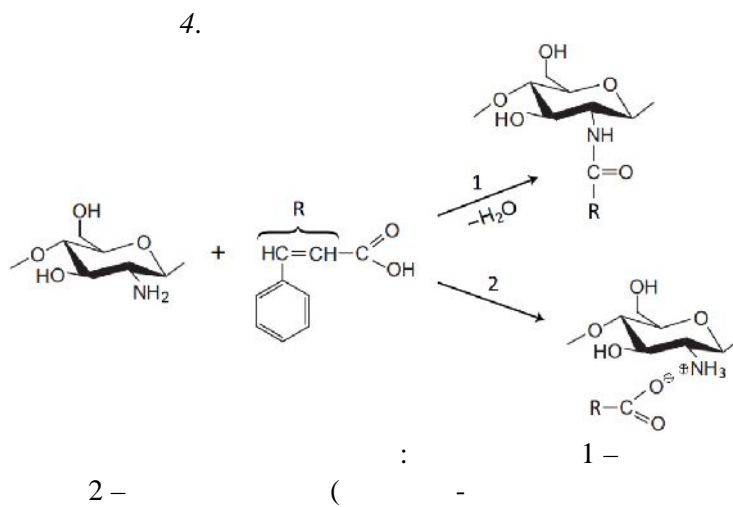
3 - - : ( ) ; ( ) - 1:1 ;  
 ( ) - 1:1

( - 1:1),  
 ( 3 ), 1383, 1540  
 1640 <sup>-1</sup>,  
 , 1640 <sup>-1</sup>  
 , = I.

550-770 <sup>-1</sup> ,  
 1628 <sup>-1</sup> 1670 <sup>-1</sup>  
 I.

( ) ,  
 1 NaOH.  
 ( 8,5-9,0).

. 3 ,  
 1383 1540 <sup>-1</sup> ( -  
 ),  
 1628 <sup>-1</sup> 1670 <sup>-1</sup>.  
 1750 <sup>-1</sup>.



0,21

0,05

( FRES-2024-0001).

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