

# KINETICS STUDY AND MECHANISM CELLULOSE CROSSING REACTIONS

Sativaldiev Aziz Kahramanovich

PhD., Associate Professor Andijan Mechanical Engineering Institute

<https://doi.org/10.5281/zenodo.10968492>

**Abstract.** *The study of reaction kinetics makes it possible to understand the mechanism of chemical interaction, determine the order and rate constant, activation energy, and also more accurately assess the activity of catalysts.*

**Keywords:** *catalyst, activation, cellulose, reaction, cross-linking, mechanism, kinetics.*

## INTRODUCTION

Finishing fabrics in the presence of catalysts consisting of organic acid and inorganic salt allows one to reduce the heat treatment temperature, but this consumes a large amount of finishing agent and catalyst. During the finishing process, acid is formed, which not only accelerates the process of cellulose cross-linking with sizing reagents, but also leads to the destruction of cellulose. However, the use of effective catalysts leads to improved quality of fabrics with less consumption of sizing reagents. [1].

When studying a particular reaction that occurs under certain conditions, an important place is occupied by the study of the kinetics of the reaction, which makes it possible to determine its optimal temperature-time parameters. The study of reaction kinetics makes it possible to understand the mechanism of chemical interaction, determine the order and rate constant, activation energy [2], and also more accurately assess the activity of catalysts.

## MATERIALS AND METHODS

The kinetics of the cellulose crosslinking reaction was studied in the presence of 180 g/l [50%] DMEM and EPA and NH<sub>4</sub>Cl catalysts at heat treatment temperatures of 90<sup>0</sup>C from 5 minutes to 60 minutes. In this case, the processing temperature was chosen as close as possible to the drying temperature of fabrics under production conditions. Fabric samples were subjected to heat treatment according to 2 options:

1. Impregnated fabrics were heat treated immediately after pulsing.
2. The pulsed fabrics were dried at room temperature and then subjected to heat treatment.

The rate of reaction of cellulose with DMEM was determined by changes in the content of bound nitrogen, formaldehyde and an increase in the crease resistance angle.

Figure 1 shows the dependence of the change in the content of bound nitrogen on the time of heat treatment at different temperatures, for the EPA and NH<sub>4</sub>Cl catalyst according to option 1 and in Figure 2 for option 2. When using the EPA catalyst, the reaction rate is higher than with NH<sub>4</sub>Cl. As can be seen from Figures 1 and 2, when modifying tissues in the presence of the EPA catalyst, a lower temperature is required to achieve the required content of bound nitrogen, and a higher temperature for NH<sub>4</sub>Cl. When modifying tissues in the presence of NH<sub>4</sub>.Cl at a temperature of 500 C, it was impossible to determine the presence of bound nitrogen due to its insignificant amount in the tissues.

## RESULTS

Studies have shown that when modifying tissues in the presence of EPA and DMEM, the formation of cross-links containing 0.85-0.95% of bound nitrogen is sufficient, when the crease resistance angle of the modified tissues is 209-230°.

Based on the maximum value of bound nitrogen, formaldehyde and crease resistance angle during heat treatment at 1400 C for 5 to 6 minutes, a graph of Ig (Amax-A) versus reaction time was plotted [5].

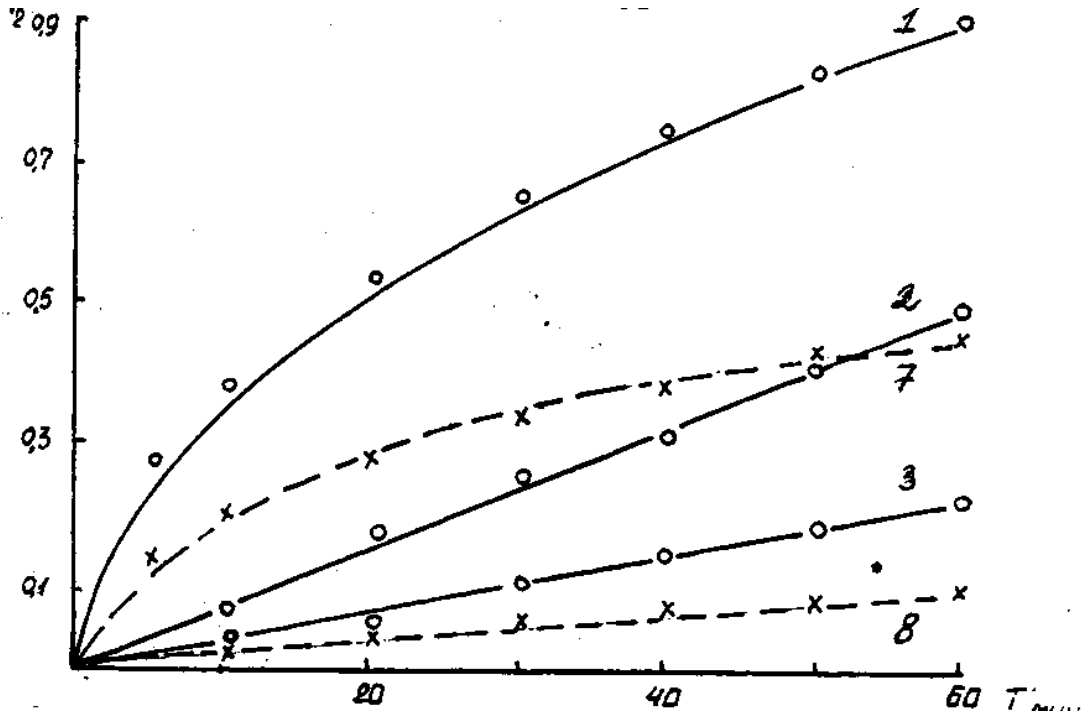


Figure 1. Dependence of changes in the content of bound nitrogen on the time of heat treatment at different temperatures

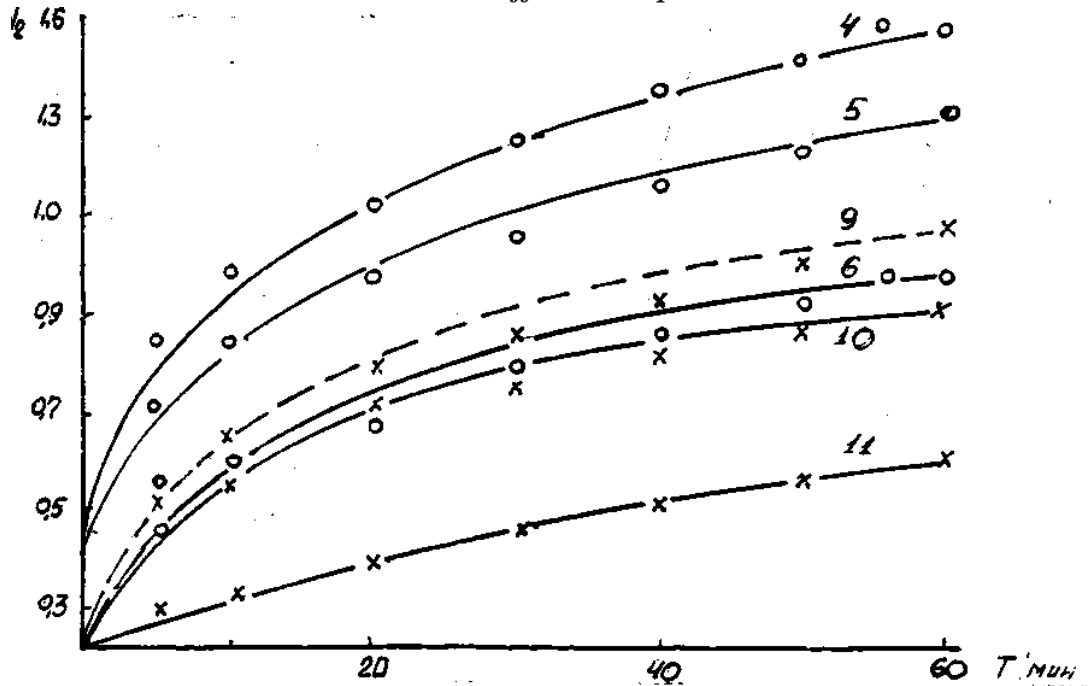


Figure 2 Dependence of bound nitrogen content on heat treatment time for EPA (curve 1-6) and NH<sub>4</sub>Cl (curve 7-11) catalysts at different temperatures

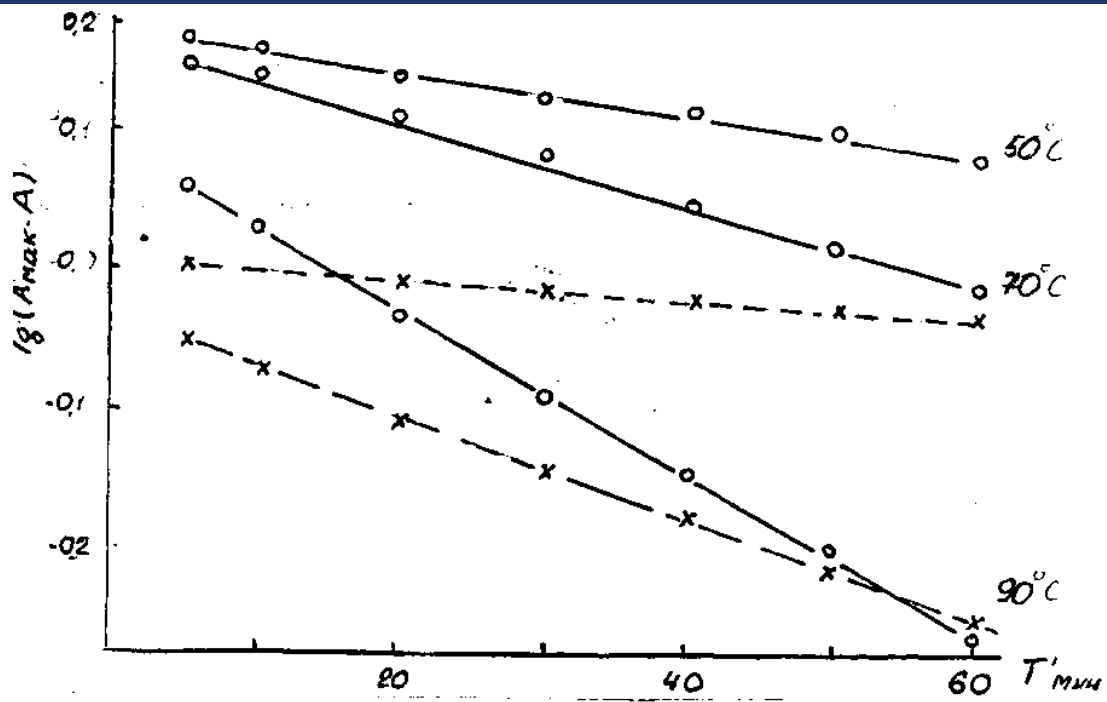


Fig.3. I-option

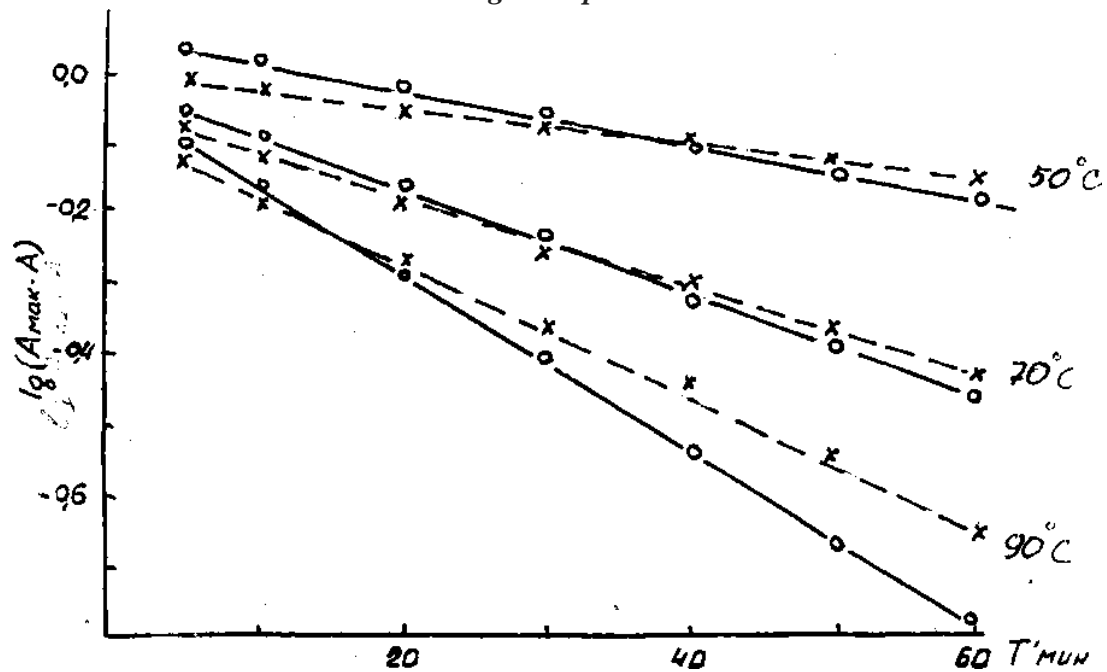


Fig.4. II-option

*Dependence of  $lg(A_{max}-A)$  on heat treatment time for EPA catalysts (curves 1-6) and  $NH_4Cl$  (curves 7-11) at different temperatures.*

Atah - maximum nitrogen content (formaldehyde) and an increase in the crease resistance angle during heat treatment at 140 °C.

A-nitrogen content (formaldehyde) and increase in the angle of persistence at time -t.

Figures 3 and 4 show the indicated dependence for EPA and  $NH_4Cl$  catalysts for both options.

### DISCUSSION

The straightness of the graph shows that the reaction of cellulose with DMEM is quite well described by the first-order reaction equation. The average value of the rate constant calculated

using the first-order reaction formula agrees well with the values found from the tangent of the straight line in coordinates  $I_g$  (Amax-A) from  $t$ .

Table 1 shows the values of the rate constants calculated for various pairs of A and t values for EPA and  $NH_4Cl$  catalysts at a heat treatment temperature of  $70^{\circ}C$ . The obtained values coincide within the scatter with the experimental points. Thus, after modifying tissues in the presence of the EPA catalyst at  $70^{\circ}C$ , the tangent of the straight line is 0.0077, which gives a rate constant value of  $1.8 \cdot 10^{-2} \text{ min}^{-1}$ .

Of greatest interest is the study of the kinetics of the cross-linking reaction of cellulose with DMEM according to the first 1st option. Since when modifying fabrics under production conditions, fabrics are subjected to temperature treatments immediately after pulsing.

When modifying tissues according to option 1, the rate of the cross-linking reaction in the presence of EPA at temperatures of  $70-900^{\circ}C$  is respectively 17.6 and 4 times higher than in the presence of  $NH_4Cl$ .

It was established that when modifying tissues in the presence of EPA and  $NH_4Cl$  at temperatures of 50, 70,  $900^{\circ}C$ , the reaction rate constants were in 1 variant, respectively: in the presence of EPA  $1.07 \cdot 10^{-2}$ ,  $1.76 \cdot 10^{-2}$ ,  $5.64 \cdot 10^{-2}$ .

In the presence of  $NH_4Cl$ ;  $1.0 \cdot 10^{-3}$  ( $70^{\circ}C$ ),  $1.4 \cdot 10^{-2}$  ( $90^{\circ}C$ ). After modification according to option 2 in the presence of EPA:  $7.4 \cdot 10^{-3}$ ,  $1.9 \cdot 10^{-1}$ ,  $3, 4 \cdot 10^{-2}$ .

**Table 1.**  
***Change in the reaction rate of DMEM with cellulose at a temperature of  $70^{\circ}C$  in the presence of EPA and  $NH_4Cl$  depending on time***

Time, min	For EPA catalyst		For $NH_4Cl$ catalyst	
	Nitrogen content, %	K EPA	Nitrogen content, %	C $NH_4Cl$
5	0,763	0,021	0,410	0,030
10	0,851	0,021	0,515	0,028
20	0,970	0,018	0,680	0,026
30	1,089	0,018	0,750	0,022
40	1,175	0,018	0,810	0,019
50	1,242	0,017	0,870	0,018
60	1,316	0,018	0,920	0,017

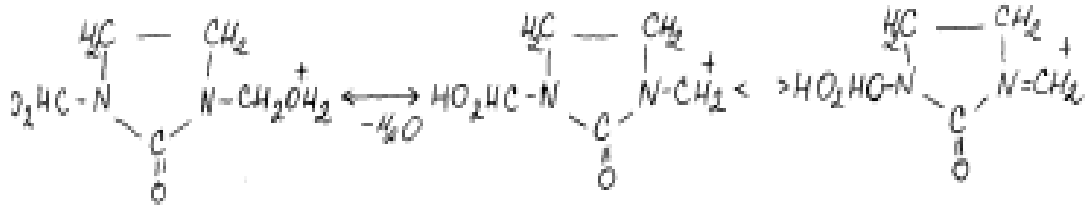
As studies have shown, an environment with the required pH can be created by introducing the EPA catalyst into the sizing solution; the pH of the sizing solution in the presence of the EPA catalyst at  $50^{\circ}C$  is 6.0, and in the presence of  $NH_4Cl$ -7.0 and  $MgCl_2$  -8.5.

### CONCLUSIONS

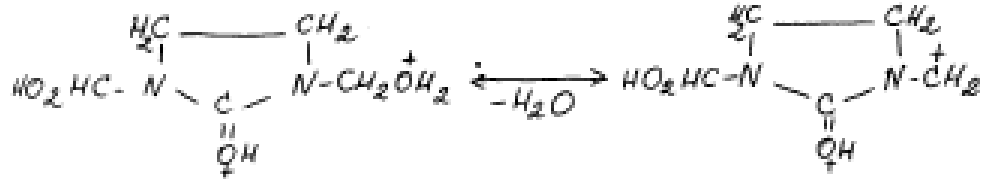
In conclusion, a study of the kinetics of the cellulose crosslinking reaction with DMEM showed that when modifying tissues in the presence of the EPA catalyst, the reaction begins at  $50^{\circ}C$ , and in the presence of  $NH_4Cl$  at  $70^{\circ}C$  and higher temperatures.

Based on the results obtained, we propose the following mechanism for crosslinking cellulose with DMEM in the presence of EPA.

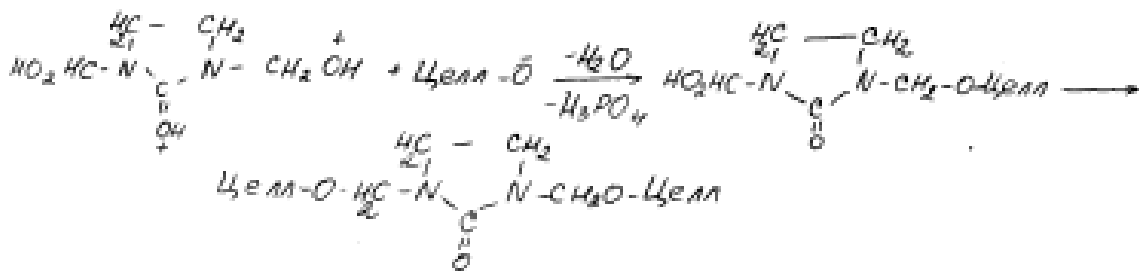
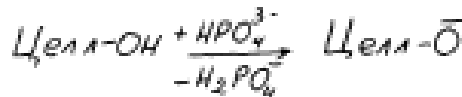
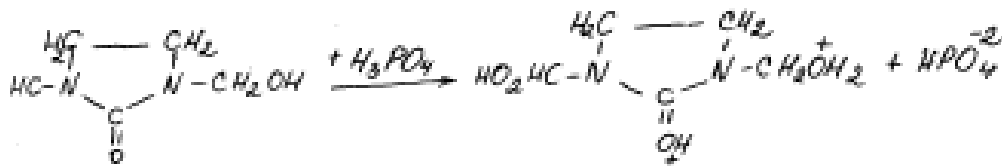
When the  $H^+$  proton attaches to the oxygen of the methylal group, the process of enolization occurs:



The addition of the H proton occurs predominantly to the carbonyl group of the DMEM molecule and, at a sufficient H concentration, the proton also attaches to the oxygen of the methylal group:



As established in the sizing solution, the components of the EPA catalyst consist of monosubstituted phosphates [3,4] and upon hydrolysis, phosphoric acid is formed:



Unlike known catalysts, when modifying tissues in the presence of an EPA catalyst, although an acidic environment is formed, the EPA components maintain the required pH environment and, due to the subsequent reaction, the reaction environment does not become strongly acidic.



## REFERENCES

1. Меликузиев Ш.М., Рузиметова Х.К., Тошпулатов Ю.Т., Лопатина В. В. Отделка х/б тканей в присутствии нового катализатора НКК.//Текст.пром-ть.-1991. -N:11-12. -С. 42-43.
2. Аристанбеков Р. Исследования влияния катализаторов сшивки целлюлозы на кинетику процесса и свойства полученных продуктов, канд. дисс. Ташкент, 1983г.-С.128.
3. Исследования смываемости катализаторов после отделки тканей. Каттаходжаева Ч.Р., Карабоев А.А., Тошпулатов Ю.Т., Адилова М.Р. Деп.ВИНИТИ 1982.N:46.
4. Каттаходжаева Ч. Р., Карабаев А.А., Ташпулатов Ю.Т. Исследования смываемости катализаторов после отделки из смешанных волокон //Науч.конф.проф.преп. состава посвящ. 50 лет обр.института: Тез. докл. -Тошкент. -1982. Ч. 1. -С. 94.
5. Эмануэль Н.К., Кнорре Д.Г. Курс химической кинетики. М.: Высшая школа., 1974г.- С.480. Сулайманов Ш. А., Сативалдиев А. К., Сулайманова М. П. ИШЛАБ ЧИҚАРИШДА НАМЛИКНИ ЎЛЧАШ УСУЛЛАРИ //Oriental renaissance: Innovative, educational, natural and social sciences. – 2022. – Т. 2. – №. 10. – С. 720-726.
6. Sativaldiyev A., Maxmudov A., Jo‘rabojev T. LOK-BO‘YOQ QOPLAMALARINI ISHLAB CHIQRISH TEXNOLOGIYALARI //Центральноазиатский журнал образования и инноваций. – 2023. – Т. 2. – №. 2. – С. 22-27.
7. Sativaldiyev A., Maxmudov A., Jo‘rabojev T. AVTOMOBILSOZLIKDA UCH O‘LCHAMLI O‘LCHOV VOSITASI YORDAMIDA O‘LCHAMLARNING ANIQLILIGINI TA‘MINLASH //Центральноазиатский журнал образования и инноваций. – 2023. – Т. 2. – №. 2. – С. 17-21.
8. Dilshodbek o‘g M. A. A. et al. LOK-BO‘YOQ MAXSULOTLARI HUSUSIYATLARI VA TURLARI //O‘ZBEKISTONDA FANLARARO INNOVATSIYALAR VA ILMIY TADQIQOTLAR JURNALI. – 2023. – Т. 2. – №. 15. – С. 577-581.
9. Сативалдиев А. К. Разработка интенсивных способов модификации целлюлозосодержащих тканей. – 1995.
10. Хакимов Д. В., Хусанова М. Ш., Фаттаев М. СТАНДАРТИЗАЦИЯ В ОБЛАСТИ ОХРАНЫ ОКРУЖАЮЩЕЙ СРЕДЫ. ЭКОЛОГИЧЕСКАЯ СЕРТИФИКАЦИЯ //Современное экологическое состояние природной среды и научно-практические аспекты рационального природопользования. – 2018. – С. 159-165.
11. Raimdjonovich X. B. et al. ASSESSMENT OF PROCESS CAPABILITY BY APPLYING THE SPC (STATISTICAL PROCESS CONTROL) METHOD TO CRITICAL CONTROL POINTS //Open Access Repository. – 2023. – Т. 4. – №. 3. – С. 1405-1410.
12. Хамдамов Б. Р., Фаттаев М. А. ПРАКТИКА ПРИМЕНЕНИЯ МЕТОДА SPC ДЛЯ АНАЛИЗА ПРОЦЕССА ПРОИЗВОДСТВА ВЕЛЮРНОГО МАТЕРИАЛА //Экономика и социум. – 2022. – №. 5-1 (96). – С. 738-742.