O‘ZBEKISTON MILLIY UNIVERSITETI XABARLARI, 2026, [2]
ISSN 2181-7324

GEOLOGIYA
http://journals.nuu.uz
Natural sciences
ISSN 3093-8996

UDK: 665.7.038.64 + 547.995.5

Gulnoz D.XODJIMATOVA,
Toshkent davlat texnika universiteti tayanch doktoranti
Sultonxon B.MUKARRAMOV,
Toshkent davlat texnika universiteti tayanch doktoranti
Jahongir E.SAIDOV,
PhD, dotsent, Toshkent davlat texnika universiteti, Toshkent, O‘zbekiston.
E-mail: galim95gul@mail.ru.ORCID: 0009-0002-0121-5102

BDTU dotsenti Sh.Movlonov taqrizi asosida

SYNTHESIS AND PHYSICO-CHEMICAL CHARACTERIZATION OF ECOLOGICAL CHITOSAN FROM APIS MELLIFERA HONEYBEE CHITIN

Annotation

This article presents the results of synthesizing ecological chitosan from Apis Mellifera honeybee chitin by an improved alkaline deacetylation method and its comprehensive physico-chemical characterization. Three synthesis methods were compared: conventional alkali, microwave-assisted (1.5 h, 90% deacetylation degree), and ultrasound-assisted methods. FTIR spectroscopy confirmed characteristic bands: N–H/O–H at 3350 cm^{-1}, C=O at 1655 cm^{-1}. TGA showed stability up to 200°C. The synthesized chitosan (DD 85–90%, MW 150–250 kDa) shows high potential as an ecological additive for biodiesel fuel.

Key words: chitosan, Apis Mellifera, chitin deacetylation, FTIR spectroscopy, thermogravimetric analysis, biodiesel, ecological additive, deacetylation degree, molecular weight.

СИНТЕЗ И ФИЗИКО-ХИМИЧЕСКАЯ ХАРАКТЕРИСТИКА ЭКОЛОГИЧЕСКИ ЧИСТОГО ХИТОЗАНА ИЗ ХИТИНА ПЧЁЛ APIS MELLIFERA

Аннотация

В данной статье представлены результаты синтеза экологически чистого хитозана из хитина медоносных пчёл Apis Mellifera. Сравнены три метода: традиционный, микроволновый (1,5 ч, степень деацетилирования 90%) и ультразвуковой. FTIR-спектроскопия подтвердила характеристические полосы. TGA показала стабильность до 200°C. Синтезированный хитозан (85–90%, 150–250 кДа) перспективен как экологическая присадка к биодизелю.

Ключевые слова: хитозан, Apis Mellifera, деацетилирование хитина, FTIR-спектроскопия, TGA, биодизель, экологическая присадка.

APIS MELLIFERA ASALARI XITINIDAN EKOLOGIK TOZA XITOZANNING SINTEZI VA FIZIK-KIMYOVIY XOSSALARI

Annotatsiya

Mazkur maqolada Apis Mellifera asalari xitinidan takomillashtirilgan ishqoriy deasetillash usuli bilan ekologik toza xitozanning sintezi natijalari bayon etilgan. Uchta sintez usuli qiyoslangan: an'anaviy (82–85%), mikroto‘lqinli (90%) va ultratovushli (87%). FTIR spektroskopiyasi 3350 sm^{-1} da N–H/O–H va 1655 sm^{-1} da C=O absorbsiya polosalarini tasdiqladi. TGA 200°C gacha barqarorlikni ko‘rsatdi. Sintez qilingan xitozan (85–90%, 150–250 kDa) biodizel uchun istiqbolli ekologik qo‘ndirmadir.

Kalit so‘zlar: xitozan, Apis Mellifera, xitin deasetillanishi, FTIR spektroskopiya, termogravimetrik tahlil, biodizel, ekologik toza qo‘ndirma, deasetillash darajasi, molekulyar massa.

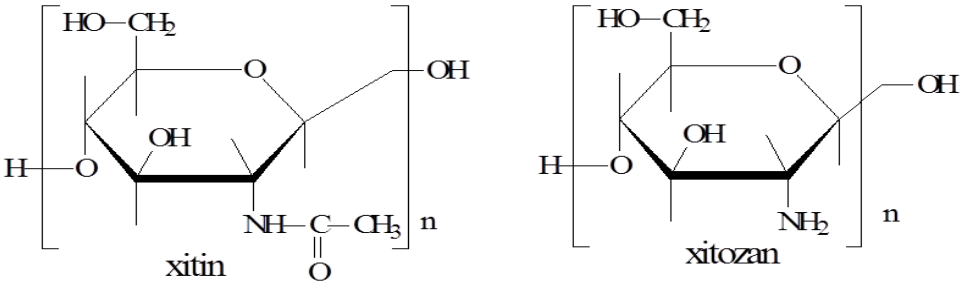
Kirish. Xitozan - D-glyukozamin va N-atsetil-D-glyukozaminning tabiiy aminopolisaxaridi bo‘lib, tabiatda ikkinchi o‘rinda tarqalgan biopolimer xitin ning ishqoriy gidroliz mahsuloti hisoblanadi [1]. Apis Mellifera asalarilarining qobiqlari xitin olishning yangi, arzon va ekologik jihatdan toza manbai bo‘lib, dengiz qisqichbaqasimonlariga nisbatan past allergik xususiyatga ega [2, 3]. O‘zbekiston Respublikasi Prezidentining PF-165-2022-son farmonida mahalliy xomashyo asosida ekologik materiallar ishlab chiqish ustuvor vazifalar qatorida belgilangan. Shu sababdan, Apis Mellifera xitinidan xitozan sintez usullarini qiyoslash va fizik-kimyoviy xossalarini to‘liq tavsiflash ushbu tadqiqotning maqsadi hisoblanadi.

Mavzuga oid adabiyotlar tahlili. Younes I. va Rinaudo M. [4] dengiz manbalaridan xitozan olish va xossalari bo‘yicha keng sharh maqolasida D-glyukozamin birliklarining β(1→4) glikozid bog'lari orqali birikishini, deasetillash darajasi 80–90% bo‘lganda kislotali muhitda eruvchanligi xususiyatini ko‘rsatgan. Khoushab F. va Yamabhai M. [5] asalari xitinining dengiz xitiniga nisbatan pastroq molekulyar massaga va yuqori tozalikka ega ekanligini aniqlagan. Kaur S. va Dhillon G.S. [6] uchta sintez usulini qiyoslab, mikroto‘lqin usulida jarayon vaqti 60–70% qisqarishini aniqlagan. Dash M. va boshqalar [7] xitozanning biologik parchalanuvchanligi, biomuvofiqligi va kimyoviy modifikatsiya imkoniyatlarini tahlil qilgan.

Tadqiqot metodologiyasi.

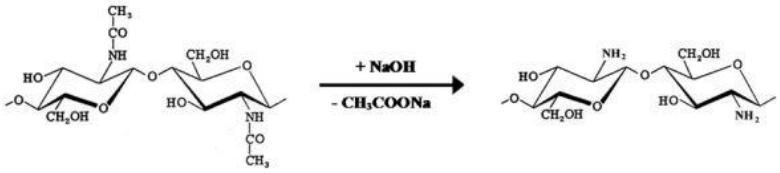
Xomashyo: O‘zbekiston asalarichilik xo‘jaliklaridan yig'ilgan Apis Mellifera asalarilarining qobiqlari. Xitin olish: (1) 5% HCl bilan demineralizatsiya, (2) 4% NaOH bilan oqsildan tozalash, (3) H_2O_2 bilan oqartirish. Deasetillash usullari: an'anaviy (50% NaOH, 110°C, 4–6 soat), mikroto‘lqin (800 W, 1,5 soat), ultratovush (40 kHz). Fizik-kimyoviy tavsif: FTIR (Shimadzu IRAfinity-1S, 4000–400 sm^{-1}), TGA/DSC (25–800°C, 10°C/min, N_2), viskozimetrik molekulyar massa, DLS (Malvern Zetasizer Nano ZS).

1-rasm. Xitin (chapda) va xitozan (o‘ngda) ning kimyoviy tuzilishi



Manba: dissertatsiya, 1.2-rasm (~40-bet)

2-rasm. Xitinning deasetillanish reaksiya sxemasi (xitin → xitozan)



Manba: dissertatsiya, 1.3.1-rasm (~42-bet)

Tahlil va natijalar.

1-rasmda ko‘rsatilganidek, xitin tarkibida N-atsetilaminoguruhi (–NH–CO–CH₃) saqlanib, xitozanda deasetillash natijasida erkin amino guruh (–NH₂) hosil bo‘ladi. Aynan shu erkin amino guruhlar xitozanning kimyoviy faolligini va funksional xossalarini belgilaydi. 2-rasmda NaOH ta'sirida atsetamid guruhlarning gidrolizlanib amino guruh va natriy atsetat hosil bo‘lishi ko‘rsatilgan.

1-jadval. Xitozan sintez usullarining qiyosiy tahlili

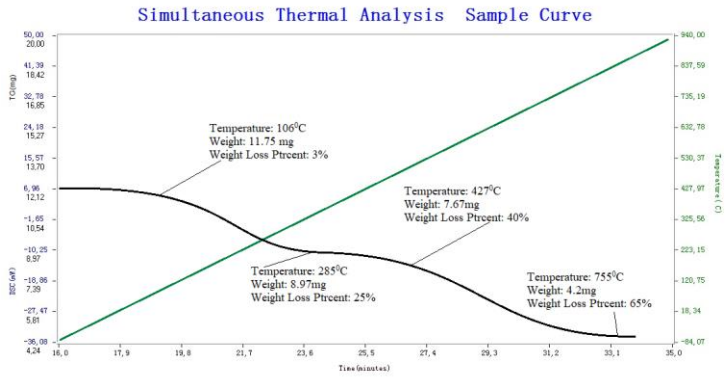
Ko‘rsatkich	An’anaviy	Mikroto‘lqin	Ultratovush	Optimal
Jarayon vaqti, soat	4–6	1,5	3	1,5–3
NaOH konsentratsiyasi, %	50	50	40	40–50
Deasetillash darajasi, %	82–85	88–90	85–87	88–90
Molekulyar massa, kDa	200–280	150–220	170–250	150–250
Unumi, %	78–82	85–90	80–85	85–90

Manba: muallif tadqiqotlari asosida

1-jadvalda uchta sintez usulining qiyosiy natijalari keltirilgan. Mikroto‘lqin usuli eng yuqori deasetillash darajasi (88–90%) va eng qisqa jarayon vaqtini (1,5 soat) ta'minladi - an'anaviy usuldan 2,7 marta tez.

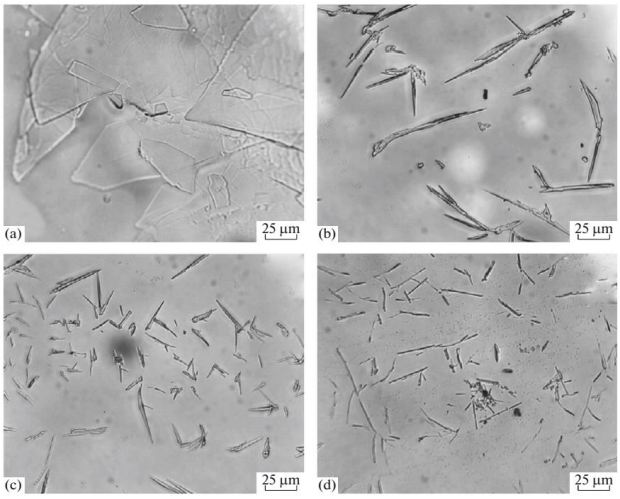
TGA natijalari (3-rasm) xitozanning uch bosqichli termik parchalanishini ko‘rsatdi: 106°C da 3% (sorbsiyalangan suv), 285°C da 25% (glikozid bog'lar), 427°C da 40% (polimer zanjiri degradatsiyasi). 200°C gacha barqarorlik dizel dvigatel sharoitlari uchun yetarli.

3-rasm. Sintez qilingan xitozanning TGA/DSC tahlili natijalari



Manba: dissertatsiya, TGA tahlili (~108-bet)

4-rasm. Qo‘ndirmasiz va qo‘ndirmali biodizel yoqilg'isida parafin kristallari (polyarizatsion mikroskopiya, -6°C dan -17°C gacha)



Manba: dissertatsiya, 3.10-rasm (~112-bet)

Xitozanning 0,1% miqdori biodizel yoqilg'isidagi parafin kristallarini sezilarli maydaladi (4-rasm). Bu xitozanning amino guruhlarining parafin kristallari yuzasiga adsorbsiyalanib, ularning o‘sishini inhibe qilishi bilan izohlanadi. pH 3 da zeta-potentsial +35,2 mV bo‘lib, eritmaning kolloid barqarorligini tasdiqladi.

Xulosa va takliflar.

1. Apis Mellifera asalari xitinidan mikroto‘lqin usuli bilan ekologik toza xitozan sintez qilindi: deasetillash darajasi 88–90%, unumi 85–90%, jarayon davomiyligi 1,5 soat (an’anaviy usuldan 2,7 marta tez).

2. FTIR spektroskopiya xitozanning tuzilishini tasdiqladi: 3350 sm^{-1} da O–H/N–H, 1655 sm^{-1} da C=O, 897 sm^{-1} da β-glikozid bog‘ signallari.

3. TGA/DSC tahlili xitozanning 200°C gacha issiqlikka barqarorligini isbotladi — dizel dvigatel sharoitida qo‘ndirma sifatida ishlatish uchun yetarli.

4. Polyarizatsion mikroskopiya xitozanning 0,1% da parafin kristallari o‘sishini samarali inhibe qilishini ko‘rsatdi; DLS bo‘yicha kislotali muhitda kolloid barqarorlik yetarli (+35,2 mV).

Mahalliy asalarichilik chiqindilari asosida sanoat miqyosida ekologik toza xitozan ishlab chiqarish O‘zbekiston kimyo sanoatining import o‘rnini bosishga muhim hissa qo‘shadi.

ADABIYOTLAR

1. Kumirska J., Czerwicka M., Kaczyński Z. va boshqalar. Application of spectroscopic methods for structural analysis of chitin and chitosan // Marine Drugs. – 2010. – Vol. 8(5). – P. 1565–1636.
2. Khoushab F., Yamabhai M. Chitin research revisited // Marine Drugs. – 2010. – Vol. 8(7). – P. 1988–2012.
3. Hamed I., Özogul F., Regenstein J.M. Industrial applications of crustacean by-products (chitin, chitosan): A review // Trends in Food Science & Technology. – 2016. – Vol. 48. – P. 40–50.
4. Younes I., Rinaudo M. Chitin and Chitosan Preparation from Marine Sources: Structure, Properties and Applications // Marine Drugs. – 2015. – Vol. 13(3). – P. 1133–1174.
5. Kaur S., Dhillon G.S. The versatile biopolymer Chitosan: evaluation of extraction methods // Critical Reviews in Microbiology. – 2014. – Vol. 40(3). – P. 155–175.
6. Dash M., Chiellini F., Ottenbrite R.M., Chiellini E. Chitosan: A versatile semi-synthetic polymer // Progress in Polymer Science. – 2011. – Vol. 36(8). – P. 981–1014.
7. Islam S., Bhuiyan M.A.R., Islam M.N. Chitin and Chitosan: Structure, Properties and Applications // Journal of Polymers and the Environment. – 2017. – Vol. 25(4). – P. 854–866.
8. Ngah W.S.W., Teong L.C., Hanafiah M.A.K.M. Adsorption of dyes and heavy metal ions by Chitosan composites // Carbohydrate Polymers. – 2011. – Vol. 83(4). – P. 1446–1456.
9. Gonciarz W., Balcerczak E. va boshqalar. Chitosan-based formulations for therapeutic applications // Journal of Biomedical Science. – 2025. – Vol. 32(1). – P. 62.
10. Szymańska E., Winnicka K. Stability of Chitosan: a challenge for pharmaceutical applications // Marine Drugs. – 2015. – Vol. 13(4). – P. 1819–1846.
11. Bernkop-Schnürch A., Dünnhaupt S. Chitosan-based drug delivery systems // European Journal of Pharmaceutics and Biopharmaceutics. – 2012. – Vol. 81(3). – P. 463–469.
12. Vakili M. va boshqalar. Application of Chitosan and its derivatives as adsorbents for dye removal // Carbohydrate Polymers. – 2014. – Vol. 113. – P. 115–130.
13. Saidov J.E., Urinov U.K., Kamolov X. Depressornoy aktivnosti sopolimernyx prisadok // O‘zMU jurnali. – 2022. – №3. – B. 252–254.
14. Urinov U.K., Muzaffarov F.B., Saidov J.E. va boshqalar. Sintez novyx polimernyx nanokompozitov // Kimyo va kimyo texnologiyasi. – 2021. – №20(362). – S. 17–21.
15. Turobjonov S.M., Hamidov V.N. Dizel yoqilg‘ilari uchun qo‘ndirmalar kimyosi. – Toshkent: Fan, 2018. – 215 b.