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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 XITIZANNING SINTEZI VA FIZIK-KIMYOVIY XOSSALARI

Annotatsiya

Mazkur maqolada Apis Mellifera asalari xitinidan takomillashtirilgan ishqoriy deasetillash usuli bilan ekologik toza xitizanning sintezi natijalari bayon etilgan. Uchta sintez usuli qiyoslangan: an'anaviy (82–85%), mikroto'liqli (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.

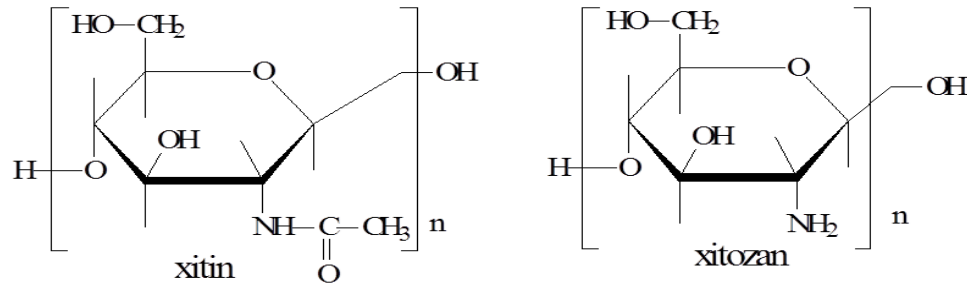
Kirish. Xitozan - D-glyukozamin va N-atsetil-D-glyukozaminning tabiiy aminopolisaxaridi bo'lib, tabiatda ikkinchi o'rinda tarqalgan biopolimer xitin ning ishqoriy gidroliz mahsuloti hisoblanadi [1]. Apis Mellifera asalarilarining qobiqlari xitin olishning yangi, arzon va ekologik jihatdan toza manbai 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 xossalarni 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 $\beta(1\rightarrow4)$ glikozid bog'lari orqali birikishini, deasetillash darajasi 80–90% bo'lganda kislotali muhitda eruvchanligi xususiyatini ko'rsatgan. Khoushab F. va Yamabhai M. [5] asalari xitininin dengiz xitinigga nisbatan pastroq molekulyar massaga va yuqori tozalikka ega ekanligini aniqlagan. Kaur S. va Dhillon G.S. [6] uchta sintez usulini qiyoslab, mikroto'liq usulida jarayon vaqti 60–70% qisqarishini aniqlagan. Dash M. va boshqalar [7] xitizanning biologik parchalanuvchanligi, biomuvofiqiqligi va kimyoviy modifikatsiya imkoniyatlarini tahlil qilgan.

Tadqiqot metodologiyasi.

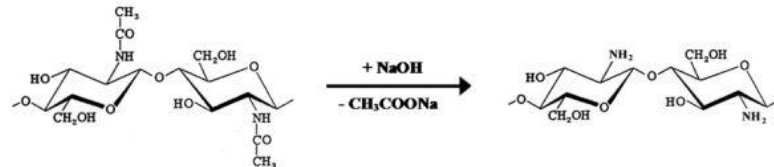
Xomashyo: O'zbekiston asalarichilik xo'jaliklaridan yig'ilgan Apis Mellifera asalarilarining qobiqlari. Xitin olish: (1) 5% HCl bilan demineralizatsiya, (2) 4% NaOH bilan oqsildan tozalash, (3) H₂O₂ bilan oqartirish. Deasetillash usullari: an'anaviy (50% NaOH, 110°C, 4–6 soat), mikroto'liq (800 W, 1,5 soat), ultratovush (40 kHz). Fizik-kimyoviy tavsif: FTIR (Shimadzu IRAfinity-1S, 4000–400 sm^{-1}), TGA/DSC (25–800°C, 10°C/min, N₂), 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 ($-\text{NH}-\text{CO}-\text{CH}_3$) saqlanib, xitozanda deasetillash natijasida erkin amino guruh ($-\text{NH}_2$) hosil bo'ladi. Aynan shu erkin amino guruhlarning 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

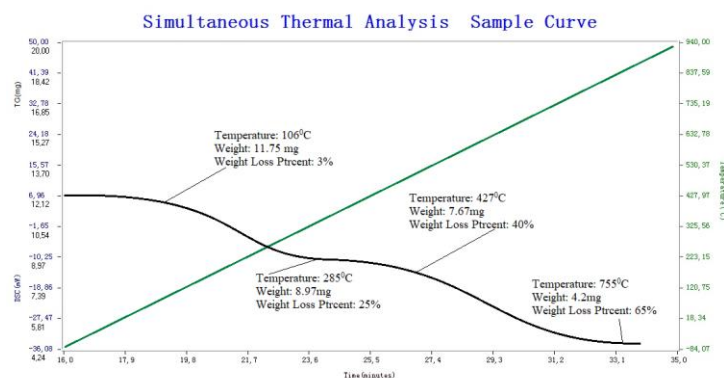
Ko'rsatkich	An'anaviy	Mikroto'lqin	Ultratovush	Optimal
Jarayon vaqti, soat	4–6	1,5	3	1,5–3
NaOH konsentratsiyasi, %	50	50	40	40–50
Deasetillash darajasi, %	82–85	88–90	85–87	88–90
Molekulyar massa, kDa	200–280	150–220	170–250	150–250
Unumi, %	78–82	85–90	80–85	85–90

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.

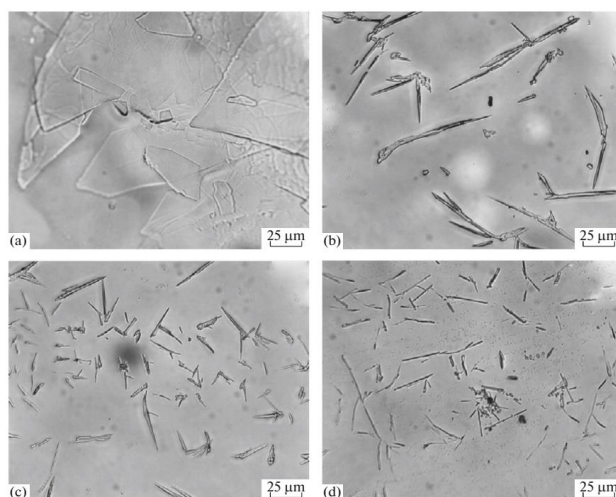
TGA natijalari (3-rasm) xitozanning uch bosqichli termik parchalanishini ko'rsatdi: 106°C da 3% (sorbsiyalangan suv), 285°C da 25% (glikozid bog'lar), 427°C da 40% (polimer zanjiri degradatsiyasi). 200°C gacha barqarorlik dizel dvigatel sharoitlari uchun yetarli.

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-potensial +35,2 mV bo'lib, eritmaning kolloid barqarorligini tasdiqladi.

Xulosa va takliflar.

1. Apis Mellifera asalari xitinidan mikroto'liq 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 cm^{-1} da O–H/N–H, 1655 cm^{-1} da C=O, 897 cm^{-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. Polarizatsion 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'rini bosishga muhim hissa qo'shadi.

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