DEVELOPMENT OF SCIENCE

ISNN 3030-3907

2026 AUGUST

ISSUE - 8
VOLUME -1

DEVELOPMENT OF SCIENCE

D E V O S

РАЗВИТИЕ НАУКИ

ILM-FAN TARAQQIYOTI

Development of science

Scientific journal
Ilmiy jurnal
Научный журнал

AUGUST 2026
Issue - 8, VOLUME - 1

ISSN 3030 -3907

*The scientific journal **«Development of Science»** was registered by the State on April 15, 2024 with certificate number №256445.*

***«Ilm fan tarqqiyoti»** ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro'yxatidan o'tgan.*

*Научный журнал **«Развитие науки»** был зарегистрирован государством 15 апреля 2024 года под номером свидетельства № 256445.*

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ISSN 3030-3907

UO‘K 543.42:546.74

NIKEL(II) IONINI 6-XLOR-4-GIDROKSI-3-NITROZONAFTALIN-2,7-DISULFOKISLOTA BILAN YANGI SPEKTROFOTOMETRIK ANIQLASH USULI

Nazirov Shohjohon Sobirovich
Ilg‘or texnologiyalar markazi.
Ixtisoslashtirilgan Atmosfera laboratoriyasi markazi, Markaziy Osiyo atrof-muhit va iqlim o‘zgarishlarini o‘rganish universiteti (Green University).
E-mail: shohjohonnazirov@gmail.com
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Xojiyev Shokir G‘ofurovich
Ilg‘or texnologiyalar markazi.

Annatatsiya. Ushbu maqolada nikel(II) ionini 6-xlor-4-gidroksi-3-nitrozonaftalin-2,7-disulfokislota (XGNDS-2,7) reagenti yordamida spektrofotometrik aniqlashning yangi usuli ishlab chiqildi. Aniqlanishicha, Ni(II) ioni XGNDS-2,7 reagenti bilan intensiv ko‘k-yashil rangli, suvda eruvchan kompleks hosil qiladi. Kompleks hosil bo‘lishining optimal sharoitlari aniqlandi: λ_{max} = 550 nm, pH = 5,5 (universal bufer), 10 μg/25 ml Ni(II) uchun 0,05 % li XGNDS-2,7 reagentining 1,2 ml hajmi yetarli ekanligi ko‘rsatildi. Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 1,0-20,0 μg/25 ml ni tashkil etdi. Kompleksning Sendel bo‘yicha sezgirligi 0,0019 μg/sm^2, kontrastligi $\Delta\lambda$ = 100 nm va haqiqiy molyar so‘ndirish koeffitsiyenti $\varepsilon = 52632$ L·mol^{-1}·sm^{-1} ga tengligi aniqlandi. Spektrofotometrik titrlash, izomolyar seriyalar va Asmus metodlari yordamida kompleksning tarkibi 1:2 ekanligi isbotlandi. Hosil bo‘lish muvozanat konstantasi (K_{muv}=0,217), barqarorlik konstantasi (lgβ=19,07) hisoblandi.

Kalit so‘zlar: nikel(II) ioni, 6-xlor-4-gidroksi-3-nitrozonaftalin-2,7-disulfokislota, spektrofotometriya, xromogen reagent, kompleks birikma, Buger–Lambert–Ber qonuni, molyar so‘ndirish koeffitsiyenti.

Abstract. A new spectrophotometric method for the determination of nickel(II) ions using 6-chloro-4-hydroxy-3-nitrosonaphthalene-2,7-disulfonic acid (CHNDS-2,7) as a reagent was developed. It was established that Ni(II) ions form an intensely colored, water-soluble blue-green complex with the CHNDS-2,7 reagent. The optimum conditions for complex formation were determined: λ_{max}=550 nm and pH=5.5 (universal buffer). It was shown that 1.2 mL of 0.05 % CHNDS-2,7 reagent is sufficient for 10 μg/25 mL of Ni(II). The concentration range obeying the Beer–Lambert law was 1.0–20.0 μg/25 mL. The Sandell

ISSN 3030-3907

sensitivity was 0.0019 μg/cm^2, the contrast Δλ=100 nm, and the true molar absorptivity coefficient ε=52,632 L·mol^{-1}·cm^{-1}. The 1:2 composition of the complex was established using spectrophotometric titration, the method of continuous variations, and the Asmus method. The complex formation equilibrium constant (K_{eq}=0.217) and stability constant (lgβ=19.07) were calculated.

Keywords: nickel(II) ion, 6-chloro-4-hydroxy-3-nitrosonaphthalene-2,7-disulfonic acid, spectrophotometry, chromogenic reagent, complex compound, Beer–Lambert law, molar absorptivity.

Аннотация. В статье разработан новый спектрофотометрический метод определения ионов никеля(II) с использованием реагента 6-хлор-4-гидрокси-3-нитрозонафталин-2,7-дисульфокислоты (ХГНДС-2,7). Установлено, что ионы Ni(II) образуют с реагентом интенсивно окрашенный сине-зелёный водорастворимый комплекс. Определены оптимальные условия комплексообразования: λ_{max}=550 нм, pH=5,5 (универсальный буфер); показано, что для 10 мкг/25 мл Ni(II) достаточно 1,2 мл 0,05 %-ного раствора реагента ХГНДС-2,7. Интервал подчинения закону Бугера–Ламберта–Бера составляет 1,0–20,0 мкг/25 мл. Чувствительность по Санделлу составляет 0,0019 мкг/см², контрастность Δλ=100 нм, а истинный молярный коэффициент поглощения ε=52632 л·моль$^{-1}$·см$^{-1}$. С использованием спектрофотометрического титрования, метода изомолярных серий и метода Асмуса доказано, что состав образующегося комплекса составляет 1:2. Рассчитаны константа равновесия комплексообразования ($K_{равн}$=0,217) и константа устойчивости (lgβ=19,07).

Ключевые слова: ион никеля(II), 6-хлор-4-гидрокси-3-нитрозонафталин-2,7-дисульфокислота, спектрофотометрия, хромогенный реагент, комплексное соединение, закон Бугера–Ламберта–Бера, молярный коэффициент поглощения.

KIRISH.

Nikel o‘tish metallari guruhiga mansub elementlardan biri bo‘lib, korroziyaga chidamli qotishmalar, galvanik qoplamalar, katalizatorlar, qayta zaryadlanuvchi batareyalar hamda boshqa funksional materiallar ishlab chiqarishda keng qo‘llaniladi[1]. Shu bilan birga, nikel ionlarining atrof-muhit obyektlari va texnologik mahsulotlar tarkibidagi miqdorini nazorat qilish ekologik xavfsizlik hamda mahsulot sifatini baholash nuqtai nazaridan muhim ahamiyat kasb etadi[2]. Shu sababli Ni(II) ionini sodda, tezkor, yuqori sezgir va selektiv

ISSN 3030-3907

usullar yordamida aniqlash analitik kimyoning dolzarb yo‘nalishlaridan biri hisoblanadi[3].

Ni(II) ionini aniqlashda atom-absorbsiya spektrometriyasi, induktiv bog‘langan plazmali optik emissiya spektrometriyasi, induktiv bog‘langan plazmali massa-spektrometriyasi, voltamperometriya hamda spektrofotometriya usullaridan keng foydalaniladi. Ushbu usullar orasida spektrofotometriya sodda bajarilishi, iqtisodiy jihatdan qulayligi, yuqori sezgirligi va murakkab asbob-uskunalarni talab qilmasligi bilan ajralib turadi. Biroq usulning selektivligi va analitik imkoniyatlari, asosan, qo‘llaniladigan xromogen reagentning kompleks hosil qilish xususiyatlariga bog‘liq[4–8].

So‘nggi yillarda Ni(II) ionini spektrofotometrik aniqlash uchun turli xromogen reagentlardan foydalanishga alohida e'tibor qaratilmoqda. Jumladan, mualliflar HPEDN (1-((4-(1-(2-gidroksifenilimino)etil)fenil)diazenil)naftalen-2-ol) azo-Shiff ligandi yordamida Ni(II) ionini spektrofotometrik aniqlash usulini ishlab chiqqanlar. Tadqiqot natijalariga ko‘ra, Ni(II)-HPEDN kompleksi λ_{max}=516 nm da maksimal yutilishga ega bo‘lib, optimal kompleks hosil bo‘lish sharoiti pH = 9,0, harorat 25 °C va reaksiya vaqti 15 min etib aniqlangan. Kompleksning stexiometrik tarkibi Me:R = 1:2 bo‘lib, Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 1,1-7,1 μg/ml ni tashkil etgan. Usulning molyar yutish koeffitsiyenti ε = 2648 $L \cdot mol^{-1} \cdot sm^{-1}$, aniqlash va miqdoriy aniqlash chegaralari mos ravishda LOD = 0,3928 μg/ml va LOQ = 1,3082 μg/ml ga teng bo‘lgan. Ishlab chiqilgan usulning natijalari alanga atom-absorbsiya spektrometriyasi natijalari bilan yaxshi mos kelgan[9].

Shuningdek, Ni(II) ionini aniqlashda 1-(2-piridilazo)-2-gidroksi-4-merkaptophenol (PAGMP) va aminofenollar asosidagi turlicha ligandli komplekslardan ham samarali foydalanilgan. Mazkur komplekslar kuchsiz kislotali muhitda (pH 3,5-6,5) hosil bo‘lib, λ_{max} = 620-650 nm da maksimal yutilishni namoyon etgan. Kompleks hosil bo‘lishi uchun PAGMP va aminofenollarning optimal konsentratsiyalari mos ravishda $(1,2\text{-}1,5)\cdot10^{-3}$ M va $(2,4\text{-}2,6)\cdot10^{-3}$ M etib aniqlangan. Kompleksning molyar yutish koeffitsiyenti ε = $(2,3\text{-}2,5)\cdot10^{4}$ $L \cdot mol^{-1} \cdot sm^{-1}$ ni tashkil etib, Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 0,5-18 μg/ml oralig‘ida kuzatilgan. Ishlab chiqilgan usul suv va tuproq namunalarida Ni(II) ionini aniqlashda muvaffaqiyatli qo‘llanilgan[10].

Bundan tashqari, 4-((imidazol-2-il)diazenil)-N-(pirimidin-2-il)benzolsulfonamid asosidagi yangi azo reagent yordamida ham Ni(II) ionini yuqori sezgirlikda spektrofotometrik aniqlash usuli taklif etilgan. Aniqlanishicha, Ni(II) ioni reagent bilan pH = 7 muhitda to‘q jigarrang rangli Me:R=1:2 tarkibli kompleks hosil qilib, λ_{max}=486 nm da maksimal yutilishni namoyon etgan. Usul uchun molyar yutish koeffitsiyenti ε = 3299 $L \cdot mol^{-1} \cdot sm^{-1}$, Sendel sezgirligi 0,0177

ISSN 3030-3907

μg/sm^2, Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 0,5-7,6 μg/ml hamda aniqlash chegarasi LOD = 0,1927 μg/ml ni tashkil etgan. Ishlab chiqilgan usul yuqori aniqlik (RSD = 0,392 %) va qayta tiklanish (Recovery = 98,7 %) ko‘rsatkichlariga ega bo‘lib, qotishma namunalarida Ni(II) ionini aniqlashda muvaffaqiyatli qo‘llanilgan[11].

Nitrozonaftalin hosilalari orasida 7-brom-2-nitrozo-1-oksonaftalin-3,6-disulfokislota (BNOKS-S-3,6) ham Ni(II) ionini aniqlash uchun samarali xromogen reagent sifatida tavsiya etilgan. Aniqlanishicha, Ni(II)-BNOKS-S-3,6 kompleksi λ_{max}=640 nm va pH = 6,5 da maksimal yutilishni namoyon etib, Buger-Lambert-Ber qonuniga 1,0-17,5 μg/25 ml konsentratsiyalar oralig‘ida bo‘ysunadi. Kompleksning stexiometrik tarkibi Me:R = 1:2 bo‘lib, Sendel bo‘yicha sezgirligi 0,0011 μg/sm^2, kontrastligi Δλ = 100 nm, molyar yutish koeffitsiyenti ε = 5,0·10^4 L·mol^{-1}·sm^{-1}, barqarorlik konstantasi lgβ = 18,87 va aniqlashning quyi chegarasi Q_{min} = 0,203 μg/25 ml ga tengligi aniqlangan. Ishlab chiqilgan usul yuqori aniqlik (Sr ≤ 0,021) bilan tavsiflanib, sun'iy aralashmalar tarkibidagi Ni(II) ionini aniqlashda muvaffaqiyatli qo‘llanilgan[12].

Tahlil qilingan adabiyotlar natijalari shuni ko‘rsatadiki, Ni(II) ionini spektrofotometrik aniqlash uchun turli xromogen reagentlar asosida sezgir va ishonchli usullar ishlab chiqilgan. Biroq ularning analitik ko‘rsatkichlari, jumladan, optimal pH qiymati, maksimal yutilish to‘lqin uzunligi, molyar yutish koeffitsiyenti, aniqlash diapazoni hamda aniqlash chegarasi reagentning kimyoviy tabiatiga bog‘liq ravishda sezilarli darajada farqlanadi. Ayniqsa, nitrozonaftalin hosilalari yuqori analitik tavsiflari bilan ajralib turishi ularning yangi hosilalarini analitik amaliyotga joriy etish istiqbolli yo‘nalish ekanligini ko‘rsatadi. Shu bilan birga, 6-xlor-4-gidroksi-3-nitrozonaftalin-2,7-disulfokislota (XGNDS-2,7) reagenti yordamida Ni(II) ionini spektrofotometrik aniqlashning analitik imkoniyatlari yetarli darajada o‘rganilmagan.

Shu munosabat bilan ushbu tadqiqotning maqsadi 6-xlor-4-gidroksi-3-nitrozonaftalin-2,7-disulfokislota (XGNDS-2,7) reagenti yordamida Ni(II) ionini spektrofotometrik aniqlashning yangi usulini ishlab chiqish, kompleks hosil bo‘lishining optimal sharoitlarini aniqlash, usulning analitik ko‘rsatkichlarini baholash hamda ishlab chiqilgan usulni sun'iy aralashmalar tarkibidagi Ni(II) ionini aniqlashda qo‘llashdan iborat.

MATERIALLAR VA METODIKALAR.

Eritmalarning spektrofotometrik tadqiqotlari Germaniyaning „EMCLAB Instruments GmbH‘‘ zavodida ishlab chiqarilgan EMC-31PC-UV spektrofotometrida o‘tkazildi. Eritmalarning pH darajasi ±0,05 pH birliklari aniqligi bilan pH metr (pH-150M OAO „ Гомельский завод измерительных приборов“) yordamida aniqlandi.

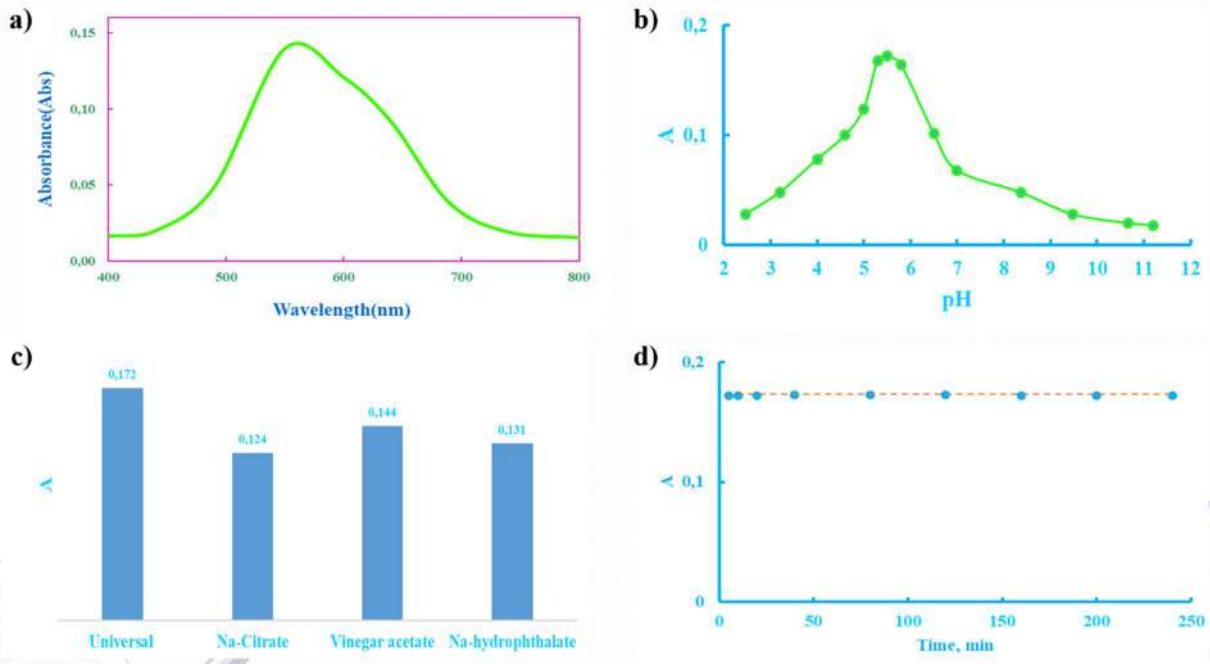
ISSN 3030-3907

Tajribaviy qism. Reaktivlar va eritmalar. T_{Cu}^{2+} = 1000 mg/ml titri bo‘lgan $CuSO_4 \cdot 5H_2O$ „kimyoviy toza‘‘ markali suvda eruvchan tuzini analitik tarozida aniq tortilgan miqdorini, 1000 ml hajmli o‘lchov kolbasiga solindi ustuga 1-2 tomchi sulfat kislota eritmasidan hamda o‘lchov chizig‘igacha bidistillangan suv qo‘shildi. Ni(II) ni kichik konsentratsiyali ishchi eritmalar standart eritmani suyultirish orqali tayyorlandi. Reagent eritmalari 0,0500 g reagentni 100 ml hajmli o‘lchov kolbasiga solindi hamda o‘lchov chizig‘igacha bidistillangan suv qo‘shildi. Turli xil pH qiymatlari bo‘lgan bufer eritmalarini tayyorlash uchun analitik kimyo bo‘yicha ma'lumotnomalardan foydalanildi.

NATIJALAR VA MUHOKAMALAR.

Ma’lumki har bir kimyoviy modda, tabiatiga ko‘ra ma’lum bir to‘lqin uzunligidagi nurlarni yutadi. Ni(II) ni 6-xlor-4-gidroksi-3-nitrozonaftalin-2,7-disulfokislota(XGNDS-2,7) reagenti bilan kompleksining eng yuqori nur yutish sohasi quyidagicha aniqlandi.

Aniqlash uslubi: 25 ml li o‘lchov kolbasiga universial bufer eritmadan 5.0 ml , 0.05 %li XGNDS-2,7 eritmasidan 1.0 ml, 15 μg/ml li Ni(II) eritmasidan 1,0 ml solib, so‘ngra kolbaning belgisigacha bidistillangan suv bilan to‘ldirildi. Hosil bo‘lgan rangli kompleks birikmaning optik zichligi EMC-31PC-UV spektrofotometrida o‘lchandi. Solishtirma eritma sifatida erkin eritma (Ni(II) dan boshqa hamma komponentlar mavjud eritma) dan foydalanildi.



1-rasm. a) Optik zichlikning to‘lqin uzuligiga bog‘liqlik grafigi; b) pH ning kompleks hosil bo‘lishiga ta'siri; c) Bufer tarkibining kompleks hosil bo‘lishiga ta'siri; d) Kompleksning vaqt bo‘yicha barqarorligi.

1a-rasmda keltirilgan natijalarga ko‘ra, hosil bo‘lgan kompleks birikma λ_{max}=550 nm to‘lqin uzunligida eng yuqori optik zichlik namoyon qildi.

ISSN 3030-3907

Ni(II) ning XGNDS-2,7 bilan rangli kompleks hosil bo‘lishining optimal sharoitlari: eritma muhitiga bog‘liqligi, bufer eritma tarkibiga bog‘liqligi, vaqtga bog‘liqligi, komponetlaring quyilish tartibiga bog‘liqligi, qo‘shilgan reagent miqdoriga bog‘liqligi o‘rganildi.

1-jadval

Kompleksning hosil bo‘lishining komponetlarning quyilish tartibiga bog‘liqligi.

(λ_{max}=550 nm, pH=5.5, n=5)

№	Komponetlarning quyilish tartibi	A
1	**Bufer-reagent-Ni(II)-dist.suv**	0,192
2	Reagent- bufer - Ni(II) - dist.suv	0,172
3	Ni(II) -bufer-reagent- dist.suv	0,168
4	Bufer - Ni(II) –reagent-dist.suv	0,164
5	Reagent- Ni(II) -bufer- dist.suv	0,159
6	Ni(II)-reagent- bufer- dist.suv	0,163
7	Ni(II) -dist.suv- bufer – reagent	0,148
8	Dist.suv-reagent-Ni(II)-bufer	0,124
9	Dist.suv-Ni(II)-bufer-reagent	0,121
10	Dist.suv-bufer-Ni(II)-reagent	0,118

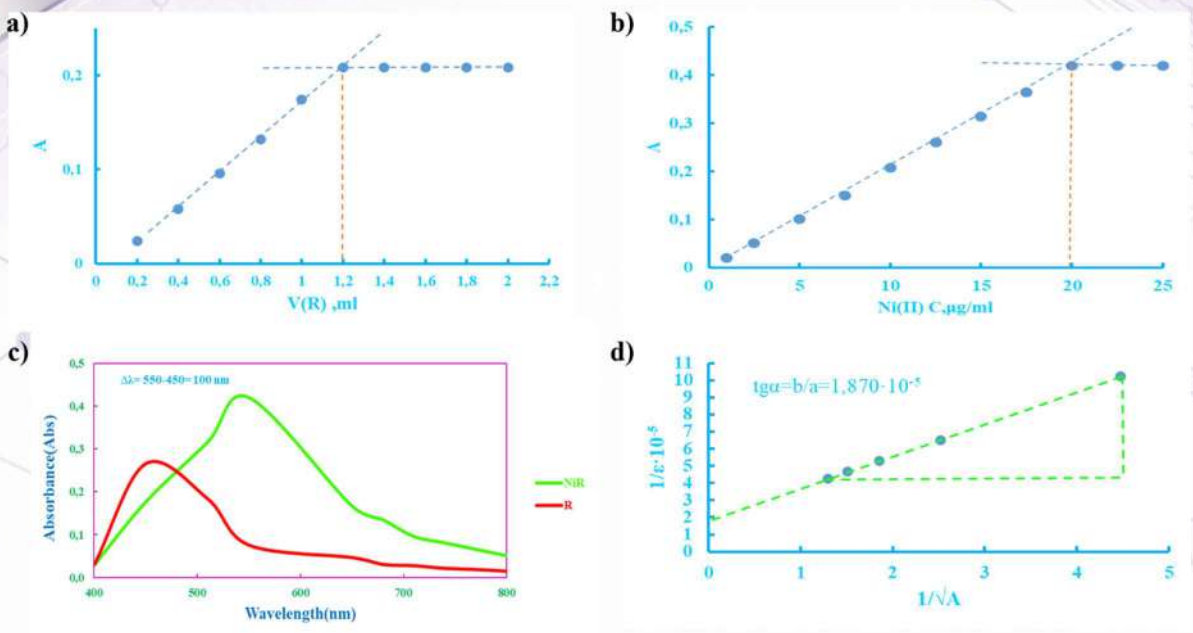
Olingan natijalar shuni ko‘rsatadiki, Ni(II) ning XGNDS-2,7 bilan rangli kompleks hosil bo‘lishining optimal sharoitlari: pH=5.5 (1b-rasm), universial buffer(1c-rasm), 240 min(1d-rasm), Bufer-reagent-Ni(II)-dist.suv(1-jadval),V_R= 1.2 ml(2a-rasm) ekanligi aniqlandi.

Buger-Lambert-Ber qonuniga bo‘ysunishi. Ni(II)ning XGNDS-2,7 bilan hosil qilgan rangli kompleks eritmasining Ber qonuniga bo‘ysunishi tanlangan optimal sharoitlarda o‘rganildi.

Aniqlash uslubi: 25 ml li o‘lchov kolbalariga 5,0 ml pH=5.5 bo‘lgan universal bufer eritma, 1.2 ml 0,05 % li XGNDS-2,7 suvli eritmasi, o‘zgaruvchan miqdorda 5 µg/ml li Ni(II)ning standart eritmasidan kolbaning belgisigacha bidistillangan suv qo‘shiladi. Eritmalarni aralashtirib optik zichliklari solishtirma eritmaga nisbatan o‘lchandi(2b-rasm).

Olingan natijalardan ko‘rinib turibdiki, Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 25 ml eritmada 1,0-20 µg/25ml gacha bo‘lgan oraliqda kuzatildi. Undan yuqori konsentratsiyalarda esa to‘g‘ri chiziqli bog‘lanishdan chetlanish ro‘y berdi.

ISSN 3030-3907



2-rasm. a) Reagent miqdorining ta'siri; b) Buger–Lambert–Ber qonuni grafigi; c) XGNDS-2,7 va Ni(II)–XGNDS-2,7 kompleksining yutilish spektrlari; d) Molyar so‘ndirish koeffitsiyentini aniqlash grafigi.

Yutilish spektrlari. XGNDS-2,7 reagenti va Ni(II) bilan hosil qilgan kompleksini tanlangan optimal sharoitda yutilish spektrlari olindi. (2-jadval, 3c-rasm). Metodning Sendel bo‘yicha sezgirligi μg/sm^2 0,001 birlik uchun nur yutilishi quyidagi formula bilan hisoblandi[13]:

$$S.s = \frac{Q \cdot \ell \cdot 0{,}001}{A \cdot 25} = \frac{20 \cdot 1 \cdot 0{,}001}{0{,}42 \cdot 25} = 0.0019\ \mu g/cm^2 \qquad (1)$$

Bu yerda: S.s-Sendel bo‘yicha segirlik, Q-olingan metall ioni miqdori, ℓ - kyuveta qalingili, A-optik zichlik.

2-jadval.

XGNDS-2,7 (HR) va uning Ni(II) bilan kompleksining(MeR) spektral tavsifi (C_{Cu2+}= 20 μg, λ_{max}=550nm, ℓ=1,0 sm, pH=5.5, n=5)

Kompleks rangi	pH	Maksimum l, nm		Δλ	C_{Me}^{2+}, μg/25 ml	C_{Me}^{2+}, mol/l	Ā	Sendel bo‘yicha sezgirlik μg/sm^2
		Me R	HR					
Kompleks Ni(II) bilan R (ℓ=1,0 sm, n=5)								
Ko‘k-yashil	5,5	550	450	100	20	$1.363 \cdot 10^{-5}$	0,420	0,0019

Tadqiqot davomida olingan natijalardan ko‘rinib turibdiki, reaksiya birmuncha kontrastlikka (Δλ=100 nm) va yuqori sezgirlikka (S.b.s=0,0019 μg/sm^2) ega ekan.

Ni(II) ning XGNDS-2,7 reagenti bilan rangli kompleks hosil qilish reaksiyasini to‘laroq o‘rganish maqsadida, asosiy tavsiflaridan kompleksning

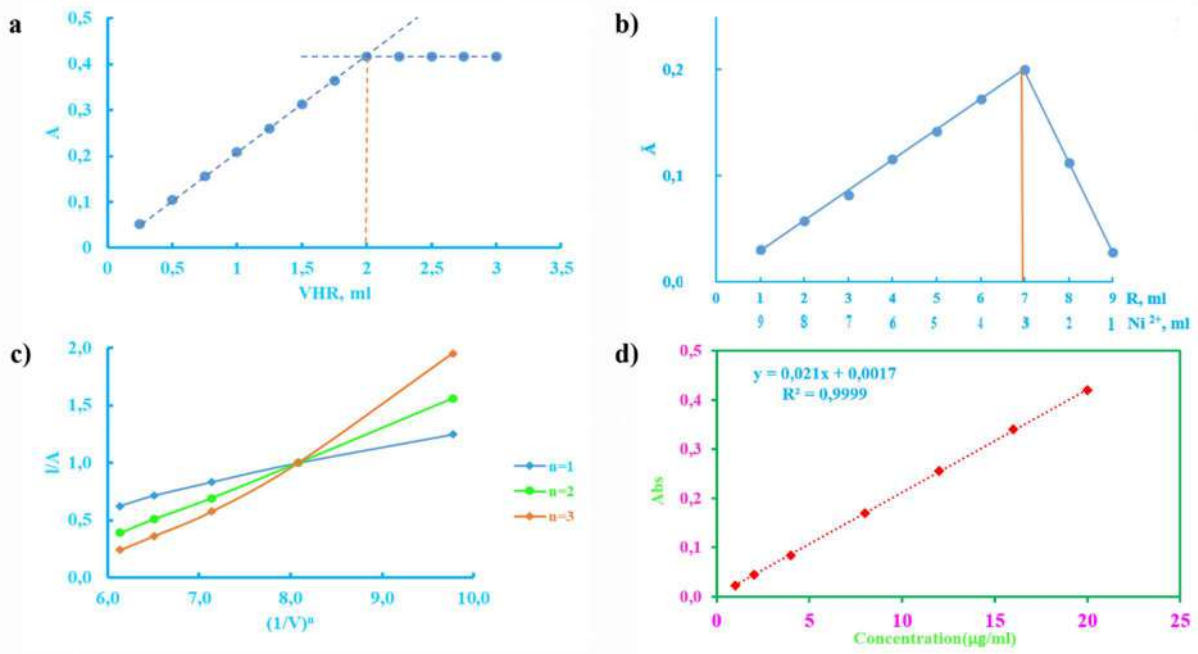
ISSN 3030-3907

haqiqiy molyar so‘ndirish koeffitsienti hamda hosil bo‘lish muvozanat konstantasi Tolmachyovning grafik metodi yordamida aniqlandi(3d-rasm).

$$\varepsilon_{haq} = \frac{1}{1/\varepsilon \cdot 10^{n}} = \frac{1}{1{,}9 \cdot 10^{-5}} = 52632 \qquad (2)$$

$$K_{muv} = \frac{C_H^n \cdot l^n}{n^n \cdot \varepsilon_x \cdot e^{n+1}} = \frac{0{,}0000173^2 \cdot 1^2}{2^2 \cdot 52632 \cdot (1{,}870 \cdot 10^{-5})^3} = 0{,}217 \qquad (3)$$

Kompleksning tarkibi va kompleks hosil bo‘lish mexanizimi. Nazarenko metodidan foydalangan holda, Ni(II) ning kompleks hosil qiluvchi shakli Cu^{2+} holatda ekanligi aniqlandi. Ni(II)ning XGNDS-2,7 bilan hosil qilgan rangli kompleksning steoxiometriyasi, spektrofotometrik titrlash metod(3a-rasm.), Izomolyar seriyalar metodi(3b-rasm.) va Asmusning to‘g‘ri chiziqli metodi(3c-rasm.) lari yordamida o‘rganildi. Olingan natijalar barcha metodlar kompleksdagi Ni:R=1:2 nisbatda ekanligini tasdiqladi.



3-rasm. a) Spektrofotometrik titrlash; b) Izomolyar seriyalar usuli; c) Asmusning to‘g‘ri chiziq usuli; d) Cu(II) ni aniqlashning kalibrlash grafigi.

Hosil bo‘lgan kompleksning barqarorlik konstantasi Babko usuli yordamida aniqlandi(3-jadval).

Bu yerda: C_H - H^+ ionlari konsentratsiyasi, l-kyuveta qalinligi, $\varepsilon_{haq.}$-kompleksning haqiqiy molyar so‘ndirish koeffitsenti, n-stexiometrik koeffitsient.

$$K_{beqaror.(MeR)} = \frac{[H^+] \cdot (A_1 \cdot C_2 - A_2 \cdot C_1)^{q+1}}{(C_1 \cdot \sqrt[3]{A_2} - C_2 \cdot \sqrt[3]{A_1}) \cdot (A_1 \cdot \sqrt[3]{A_2} - A_2 \cdot \sqrt[3]{A_1})^{q}} \qquad (4)$$

$$K_{barqaror.(MeR)} = \frac{1}{K_{beqaror.(MeR)}} \qquad (5)$$

ISSN 3030-3907

Bu yerda: $[H^+]$-vodorod ionlari konsentratsiyasi, A_1, A_2-optik zichliklar, C_1, C_2-metall ioni konsentratsiyalari.

Olingan natijalar shuni ko‘rsatdiki, Ni(II) ning XGNDS-2,7 reagenti bilan hosil qilgan rangli kompleksning ε_{haq}=52632, K_{muv}=0.217 va lgβ=19.07 qiymatlariga ega ekanligi aniqlandi. Olingan natijalardan shunday xulosa qilish mumkinki, ishlab chiqilgan usul yuqori sezgirlikka, kompleks birikma esa o‘rtacha barqarorlikka ega ekanligi aniqlandi.

3-jadval.

Babko usuli yordamida kompleksning barqarorlik konstantasini aniqlash natijalari

№	$V_{Cu^{2+}}$, ml	V_{R1}, ml	$C_1 \cdot 10^{-6}$	A_1	$C_2 \cdot 10^{-6}$	A_2	$K_{beqaror}$ (MeR)	$K_{barqaror}$ (MeR) (β_k)	$lgK_{barqaror.}$ (MeR) ($lg\beta_k$)
1	0,5	1	3,41	0,050	1,71	0,024	$1,04 \cdot 10^{-19}$	$2,17 \cdot 10^{18}$	18.98
2	1	2	6,82	0,154	3,41	0,075	$2.95 \cdot 10^{-20}$	$7,75 \cdot 10^{19}$	19.53
3	1,5	3	10,23	0,291	5,12	0,143	$6.65 \cdot 10^{-20}$	$3,42 \cdot 10^{19}$	19.18
4	2	4	13,64	0,463	6,82	0,227	$1.18 \cdot 10^{-19}$	$7,14 \cdot 10^{18}$	18.93
5	2,5	5	17,05	0,633	8,53	0,310	$1.85 \cdot 10^{-19}$	$3,20 \cdot 10^{18}$	18.73
Σ							$1,01 \cdot 10^{-19}$	$8,09 \cdot 10^{19}$	19.07

Graduirovkali grafik natijalarini kichik kvadratlar usuli bilan matematik qayta ishlandi shu bilan bergalikda to‘g‘iri chiziqli matematik tenglamasi tuzildi(3d-rasm).

Olingan natijalardan kelib chiqib graduirovkali grafik (darajalangan grafik) to‘g‘ri chiziq tenglamasi $Y_i = aX_i + b$ ya’ni $Y_i = 2.1 \cdot 10^{-2} X_i + 1.3 \cdot 10^{-3}$ ishlab chiqildi.

XULOSA. Ni(II) ionini XGNDS-2,7 reagent bilan kompleks hosil bo‘lishining optimal sharoitlari o‘rganildi: pH=5.5, universial buffer, 240 min, Bufer-reagent-Ni(II)-dist.suv,V_R=1.2 ml. Buger-Lambert-Ber qonuniga bo‘ysunish sohasi 1-20 μg/25ml, S.b.s= 0,0019 μg/sm^2, Δλ=100 nm. Spektrofotometrik titrlash metodi, Izomolyar seryalar metodi va Asmusning to‘g‘ri chiziq metodi yordamida tarkib Me:R=1:2 ekanligini tasdiqladi. Tolmachyovning grafik metodi yordamida hosil bo‘lgan kompleksning haqiqiy molyar so‘ndirish koeffitsienti(ε_{haq}=52632) va hosil bo‘lish muvozanat konstantasi (K_{muv}=0.217),

ISSN 3030-3907

Babko usuli yordamida rangli kompleksning barqarorlik konstantasi(lgβ=19.07) aniqlandi. Graduirovkali grafik (darajalangan grafik) to‘g‘ri chiziq tenglamasi $Y_i = 2{,}1 \cdot 10^{-2} X_i + 1{,}3 \cdot 10^{-3}$ ishlab chiqildi.

Minnatdorchilik

Mazkur tadqiqot Ilg‘or texnologiyalar Markazi va *Markaziy Osiyo atrof-muhit va iqlim o‘zgarishlarini o‘rganish universiteti (Green University) lari*ning byudjet mablag‘lari hisobidan moliyalashtirildi.

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