CHEMISTRY AND CHEMICAL ENGINEERING

Volume 2024 | Number 3 Article 4

September 2024

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Recommended Citation

RUZMATOV, Eldor I.; ARIPOVA, Mastura Kh.; and Ro'ziboyev, Bahrom R. (2024) "STUDY OF CRYSTALLIZATION ABILITY OF GLASSES SYNTHESIZED IN THE BASALT-QUARTZ-SODA SYSTEM," *CHEMISTRY AND CHEMICAL ENGINEERING*: Vol. 2024: No. 3, Article 4.
DOI: https://doi.org/10.34920/cce202434
Available at: https://cce.researchcommons.org/journal/vol2024/iss3/4

STUDY OF CRYSTALLIZATION ABILITY OF GLASSES SYNTHESIZED IN THE BASALT-QUARTZ-SODA SYSTEM

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The aim of the work is to study the crystallization capacity of glasses synthesized in the basalt-quartz-soda system. The crystallization capacity of glasses was studied by the method of mass crystallization in the range of 600 °C and 1050 °C. The stages of spontaneous crystallization were determined by the DTA method. The density, TCLE, refractive index, compressive strength and frost resistance were studied. The crystalline phases of crystallized glasses were determined by the X-ray phase method. The presence of diopside and anorthite was revealed.

Keywords: colored glass, basalt, crystallization, temperature, properties

ИССЛЕДОВАНИЕ КРИСТАЛЛИЗАЦИОННОЙ СПОСОБНОСТИ СТЕКОЛ, СИНТЕЗИРОВАННЫХ В СИСТЕМЕ БАЗАЛЬТ-КВАРЦ-СОДА

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Целью работы является исследование кристаллизационной способности стекол, синтезированных в системе базальт-кварц-сода. Исследована кристаллизационная способность стекол методом массовой кристаллизации в интервале 600 °С и 1050 °С. Определены этапы самопроизвольной кристаллизации методом ДТА. Изучены плотность, ТКЛР, показатель преломления, прочность на сжатие и морозостойкость. Рентгенофазовым методом определены кристаллические фазы закристаллизованных стекол. Выявлено наличие кристаллов диопсида и анортита.

Ключевые слова: цветные стекла, базальт, кристаллизация, температура, свойства

BAZALT-KVARTS-SODA TIZIMIDA SINTEZ QILINGAN SHISHALARNING KRISTALLANISH QOBILIYATINI O'RGANISH

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Ishning maqsadi bazalt-kvarts-soda tizimida sintez qilingan shishalarning kristallanish qobiliyatini o‘rganishdir. 600 °C va 1050 °C oralig‘ida massaviy kristallanish usuli bilan shishalarning kristallanish qobiliyati o‘rganildi. DTA tahlili yordamida shishalarning nukleatorlarsiz kristallanish qobiliyati aniqlandi. Shishakristall namunalarning zichligi, TCHKK, nur sindirish ko‘rsatkichi, mexanik siqilishga mustaxkamlik darajasi va sovuqqa bardoshliligi o‘rganildi. Rentgen tahlili yordamida kristallangan shishalarning kristall fazalari o‘rganilib, diopsid va anortitning kristallari mavjudligi aniqlandi.

Kalit so'zlar: rangli shishalar, bazalt, kristallanish, harorat, xossalar

DOI: 10.34920/cce202434

Kirish

Shisha ishlab chiqarish texnologiyasi tabiiy va texnik xomashyolardan foydalangan holda turli sohalar uchun kerakli bo‘lgan estetik jihatdan nafis va bezakbop materiallarni sintez qilish imkoniyatini ochadi. Shishaning kashf etilishi tufayli yillar davomida turli shakldagi idishlar, tarali shihsalar, deraza oynalari qisqacha qilib aytganda, jamiyat turmush tarzi uchun zarur bo‘lgan buyumlarni ko‘plab ishlab chiqarilishiga olib keldi [1-5].

Hozirgi vaqtda dunyoda zamonaviy va modernizatsiya qilingan binolar hamda inshootlarni qurishda ichki va jabhani dekorativ jihatdan bezash muhim ahamiyatga ega. Arxitekturada binolarning tashqi va ichki dizaynini estetik hamda funksional yaxshilashda shisha buyumlardan foydalanish asosiy omillardan biri hisoblanadi [6-8].

Shishalarni bir yoki ikki bosqichda termik ishlov berish orqali yuqori xususiyatarga ega bo‘lgan shishakristall materiallar olish mumkin [9-12]. Maxsus texnologiya yordamida yuqori mexanik mustahkamlikga, termik kengayish koeffisienti darajasi past va tashqi ta’sirlarga yuqori qarshilikga ega bo‘lgan materiallar shishakristall materiallar deb ataladi [13-14]. Tog‘ jinslari asosida olingan shishakristall materiallar yuqori fizik-kimyoviy xossalarga ega bo‘lib ulardan binolarning tashqi fasadlarini bezashda yoki zinapoyalarni qoplashda hamda pol uchun koshinlar sifatida foydalaniladi [15-17]. Yer yuzida eng ko‘p tarqalgan va boshqa xomashyolarga nisbatan arzon bo‘lgan basalt tog‘ jinsi shishakristall materiallar ishlab chiqarishda keng qo‘llaniladi [18-20].

Ushbu tadqiqotning maqsadi basalt-kvarts-soda tizimida sintez qilingan optimal tarkibli shishalarning kristallanish qobiliyatlarini o‘rganishdan iborat. Shishalar sintezi uchun Osmonsoy koni bazalti, Samarqand kvarts qumi va Qo‘ng‘irot texnik sodasi qo‘llanilgan.

1-jadval

Basalt-kvarts-soda tizimida sintez qilingan shishalarning kimyoviy tarkibi

Shisha indeksi	Oksidlarning miqdori, %												
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	Cr_2O_3	ZnO	MnO	CuO	SO_3
2	55,6	11,7	7,78	7,48	3,06	10,2	0,95	1,83	0,015	0,0116	0,108	0,007	0,104
3	59,5	10,1	6,91	6,74	2,71	9,95	1,14	1,62	0,014	0,010	0,097	0,005	0,070
9	65,0	8,77	5,85	5,71	2,28	9,46	0,98	1,37	0,012	0,008	0,081	0,006	0,057
11	71,5	3,58	1,25	1,36	0,41	20,0	1,21	0,32	0,003	0,002	0,019	0,002	0,059
15	58,8	6,04	3,80	3,75	1,43	21,0	0,97	0,88	0,007	0,0055	0,054	0,004	0,098
20	49,8	12,8	6,84	7,62	3,10	17,0	0,60	1,71	0,010	0,008	0,099	0,006	0,126
21	50,9	13,2	8,53	9,61	3,33	10,8	0,69	2,14	0,011	0,012	0,116	0,006	0,151
22	52,5	10,5	7,11	6,23	2,81	17,6	0,81	1,74	0,013	0,008	0,097	0,006	0,074
23	55,7	8,13	5,86	5,98	2,20	15,4	0,87	1,36	0,012	0,009	0,054	0,005	0,181
26	44,0	10,8	3,71	3,72	1,50	24,5	0,88	0,88	0,007	0,005	0,055	0,004	1,380
32	72,4	4,29	2,37	2,48	0,85	15,0	0,98	0,57	0,005	0,005	0,036	0,003	0,057
33	72,8	4,37	2,44	2,47	0,86	15,1	0,98	0,56	0,004	0,006	0,038	0,003	0,050

Tadqiqot usullari

Shishakristall namunalarning fazaviy tahlili CuK yordamida XRD-6100 apparatida (Shimadzu, Yaponiya) qayd etilgan diffraktsion tasvirlar asosida amalga oshirildi. - radiatsiya (b - filtr, Ni, 1.54178 quvur oqimi va kuchlanish rejimi 30 mA, 30 kV) va doimiy detektor aylanish tezligi 4 daraja / min 0,02 daraja qadam bilan va skanerlash burchagi 4 dan 80 ° gacha o‘zgarib turadi.

Shishakristall namunalarning fizik-kimyoviy xossalari GOST 13996-2019 talablari bo‘yicha aniqlandi

Natijalar va muhokama

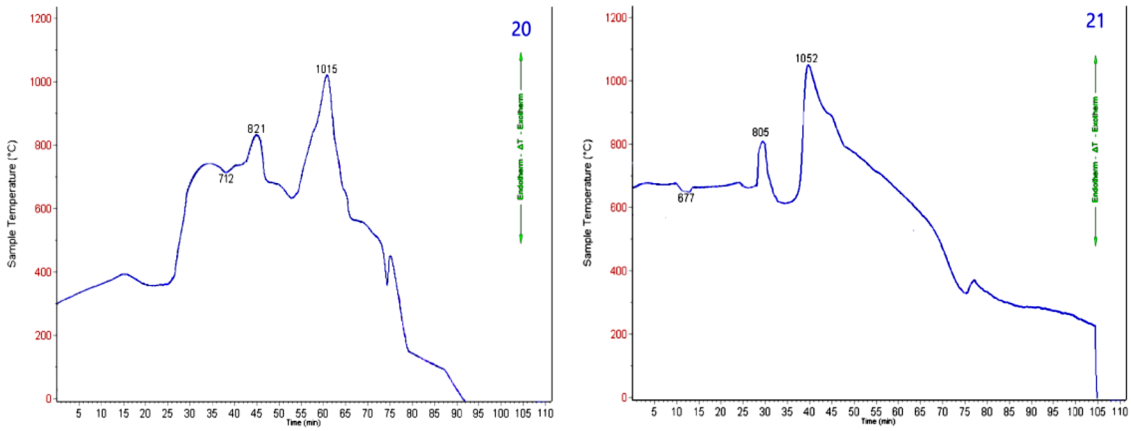
Basalt-kvarts-soda tizimida sintez qilingan shishalarning kimyoviy tarkibi 1-jadvalda keltirilgan.

1-jadvaldagi ma’lumotlardan ko‘rinib turibdiki, basalt–kvarts–soda tizimida sintez qilingan shishlarning kimyoviy tarkibida Fe_2O_3, TiO_2, Cr_2O_3, va MnO rang beruvchilarning mavjudligi jigarrang, qora, firuza, yashil, och havorang va sariq rangli shishalar olish imkonini bergan [21]. Olingan shishalarning fizik-kimyoviy xossalari quyidagi 2-jadvalda keltirilgan.

2-jadval

Bazalt-kvars-soda tizimida sintez qilingan optimal tarkibli shishalarning fizik-kimyoviy xossalari

Shisha indeksi	Zichligi, kg/m^3	TCHKK $\cdot 10^7$, K^{-1}	Nur sindirish ko‘rsatkichi, *n*	Mexanik egilishga mustahkamlik darajasi, MPa	Sovuqqa bardoshliligi, tsikl
2	2743	84	1,471	50	37
3	2694	83	1,470	52	37
9	2675	79	1,468	49	38
11	2481	112	1,466	35	34
15	2621	119	1,462	37	33
20	2760	112	1,476	38	35
21	2766	87	1,474	55	40
22	2728	110	1,474	34	34
23	2676	104	1,482	36	35
26	2648	94	1,477	44	36
32	2584	115	1,464	33	33
33	2512	88	1,476	41	36
GOST P 54169 –2010	2480 –2700	80 – 120	1,4 – 1,5	15 – 45	30-35



1-rasm. Bazalt-kvars-soda tizimida olingan shisha namunalarining termogrammasi.

2-jadvaladagi ma'lumotlardan bazalt–kvars–soda tizimida sintez qilingan optimal tarkibli shishalarning fizik-kimyoviy xossalari GOST P 54169–2010 talablariga to'liq javob berishi aniqlandi.

Ma'lumki shishakristall materiallar olishda shishalarning kritsallanish bosqichlari muhim ahamiyatga ega bo'lib, bu jarayon differensial termik tahlil usuli orqali aniqlanadi [22]. Shu maqsadda bazalt-kvars-soda tizimida sintez qilingan shishalarning kristallanish haroratlari aniqlandi va natijalar quyidagi 1-rasmda keltirilgan.

1-rasmdagi natijalarga ko'ra, shisha kristallanishi ikki bosqichda sodir bo'ladi deb xulosa qilindi: 600-800 °C harorat oralig'ida birinchi bosqich kristall markazlarning shakllanishi va ikkinchi bosqich - taxminan 1050 °C haroratda kristallanishning o'sishi. Olingan tahlil natijalarini hisobga olgan holda, shishalarning kristallanish qobiliyati massaviy kristallanish usuli yordamida o'rganildi (3-jadval).

3-jadval

Bazalt–kvars–soda tizimida olingan shishalarning kristallanish qobiliyati

Shisha indeksi	Harorat ta'sirida kristallanish darajasi					
	600 °C	700 °C	800 °C	900 °C	1000 °C	1050 °C
2						
3						
9						
11						
15						
20						
21						
22						
23						
26						
32						
33						

Kristallanish turi: - kristallanish belgilari yo'q - kichik ajratilgan sohalarda sirt tomondan kristallanish - uzluksiz yupqa qoplam shaklida sirt kristallanishi - qisman taqsimlangan qalin qobiq shaklida yuza kristallanishi - kristallanishning namunada butun hajm bo'ylab tarqalishi - shishalarda erish jarayonining boshlanishi - to'liq hajmli kristallanish.

Shishalarning kristallanish qobiliyati 600-1050 °C harorat oralig‘ida issiqlik bilan ishlov berish orqali o‘rganildi, ushlab turish vaqti 1 soatni tashkil etdi. Tajribalar natijasida 2, 3, 9, 20 va 21-tarkibli shisha namunalari 1050 °C haroratda to‘liq kristallanishi aniqlandi. 22-tarkibli shisha namunasi 1000 °C haroratda shartli ravishda to‘liq kristallandi va harorat oshishi bilan erish jarayoni kuzatildi.

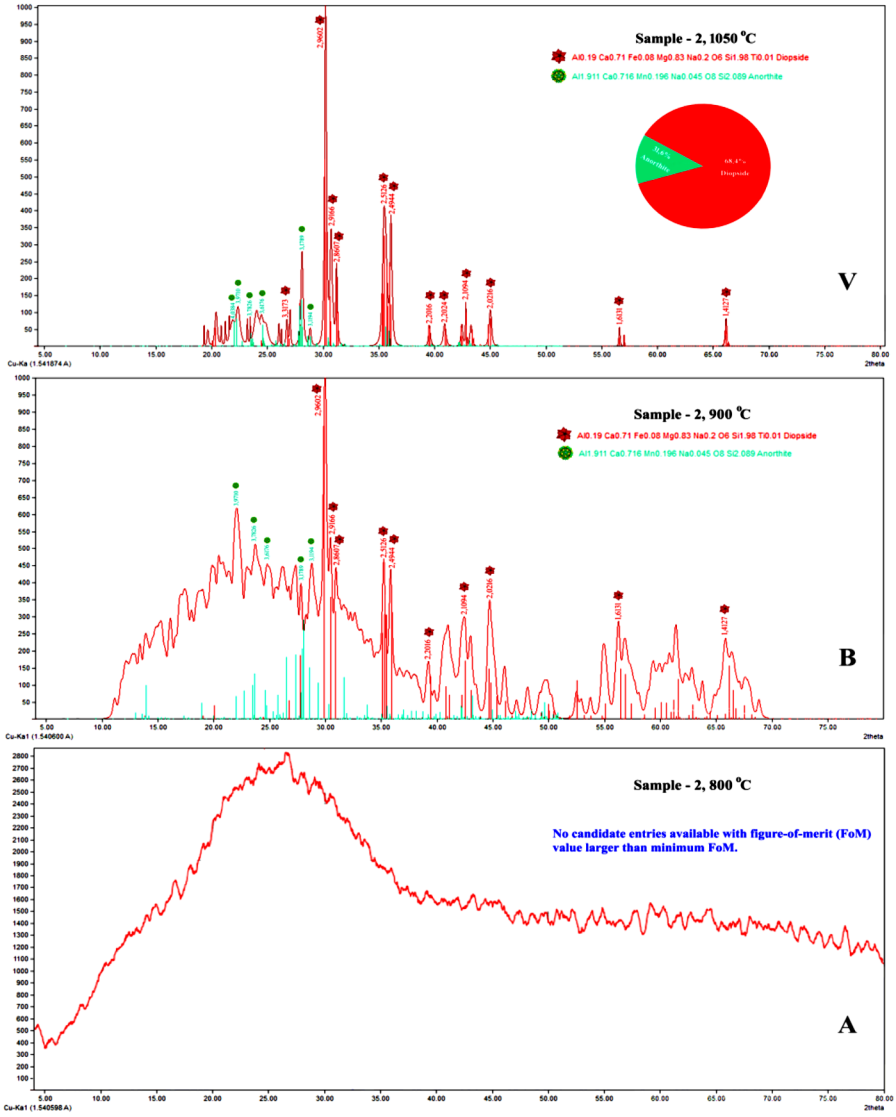
Bazalt-kvars-soda tizimida sintez qilingan shishalarning kristallanish qobiliyatini tahlil qilish natijasida 700 °C haroratda shisha namunalarida kristall markazlarning shakllanishi va 1050 °C haroratda to‘liq kristallanish aniqlandi.

Rentgen tahlil natijalari shuni ko‘rsatdiki, 2 -tarkibli shisha namunalariga 800 °C, 900 °C va 1050 °C haroratlarda issiqlik bilan ishlov berish jarayonida faza o‘zgarishlari sodir bo‘lgan - amorf fazaning to‘liq yo‘qolishi va harorat 1050 °C yetganda diopsid va anortit fazalarining hosil bo‘lishi kuzatildi (2-rasm). Diopsid kristall fazalari miqdori 68,4% va anortit 31,6% ni tashkil qiladi.

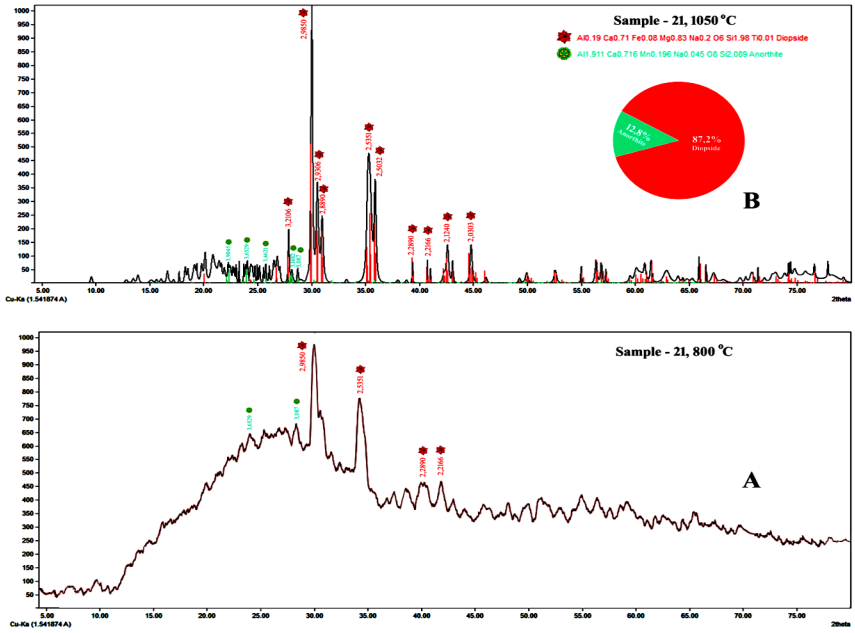
800 °C va 1050 °C haroratlarda 21-tarkibli shisha namunalariga issiqlik bilan ishlov berish jarayonida 2-tarkibli shisha namunaga nisbatan diopsid bilan bog‘liq bo‘lgan fazalar intensivligining oshishi kuzatildi. 3-rasmda olingan difraktogrammalardan aniq ko‘rinib turibdiki oldinroq ya’ni 800 °C haroratda diopsid (d = 2, 2166; 2,2890; 2,5351; 2,9850 Å) va anortit (d = 3,087; 3,6529 Å) hosil bo‘ladi.

Bazalt–kvarts–soda tizimida olingan shishakristall namunalarning fizik-kimyoviy xossalari quyidagi 4-jadvalda keltirilgan.

Shishakristall koshinlarning kristallanish darajasi ularning yuqori zichligi, shuningdek, past TCHKK qiymati bilan belgilanadi. Tahlil natijalari



2-rasm. 2–takibli shisha namunalarining A – 800 °C, B – 900 °C, V – 1050 °C haroratlarda kristallangan difraktogrammasi.



3-rasm. 21–tarkibli namunalarining A - 800 °C, B - 1050 °C haroratlardagi difraktogrammasi.

shuni ko'rsatdiki, Osmonsoy bazalti, Samarqand kvars qumi va Qo'ng'irot sodasi asosida sintez qilingan shishani kristallash yo'li bilan olingan shishakristall namunalarining zichligi 2940 – 3100 kg/m^3, TCHKK qiymati 53 – 64 K^{-1} oralig'ida. Ushbu ko'rsatkichlar namunalarning yetarlicha yuqori kristallanish darajasini ko‘rsatadi. Shisha texnologiyasidan foydalangan holda olingan shisha kristall namunalarining egilish kuchi 108-120 MPa, bosim kuchi esa 700-810 MPa oralig‘ida. 3-jadvaldagi ma’lumotlarda, kristallangan shisha suvning yutuvchanligi - 0,009% dan kam, yuqori sovuqqa bardoshliligi - kamida 112 tsikl va yuqori kislotaga bardoshliligi (HCl kons.: 97,52-99,94%; H_2SO_4 kons.: 96,80-99,89%) keltirilgan.

Xulosa

Mahalliy xomashyolar asosida bazalt–kvars–soda tizimida bo‘yovchi qo‘shimchalardan foydalanmagan holda jigarrang, qora, firuza, yashil, och havorang va sariq rangli shisha namunalari sintez qilingan.

4-jadval

Shishakristall namunalarning fizik-kimyoviy xossalari

№	Xossalar		Tarkiblar						
			2	3	9	20	21	22	GOST 13996-2019
1	Zichlik, kg/m^3		3089	3038	3010	2987	3100	2940	–
2	TCHKK•10^7, K^{-1}		55	57	58	60	53	64	–
3	Mexanik egilishga mustahkamlik darajasi, MPa		119	116	113	111	120	108	15-35
4	Mexanik siqilishga mustahkamlik darajasi, MPa		794	762	745	720	810	700	–
5	Suv yutuvchanlik, %		0,003	0,003	0,005	0,007	0,001	0,009	0,5
6	Sovuqqa bardoshlilik, tsikl		137	134	129	116	145	112	100
7	Kislotalarga bardoshlilik, %	konst. HCl	99,49	98,68	98,45	98,07	99,94	97,52	–
		konst. H_2SO_4	98,51	98,34	98,16	97,23	99,89	96,80	–

Sintez qilingan rangli shishalarning zichligi 2481-2766 kg/m^3, sovuqqa bardoshliligi 34-40 tsikl, mexanik egilishga mustahkamlik darajasi 33-55 MPani tashkill etib, GOST 54169-2010 talablarini qanoatlantirdi.

Bazalt–kvarts–soda tizimida sintez qilingan shishalarning kristallanish jarayoni ikki bosqichdan iborat bo‘lib, birinchi bosqich 800 ° C va ikkinchi bosqich 1050 °C haroratni tashkil etadi.

Shishalarning ikki bosqichda kristallanishi natijasida diopsid va anortit fazalarining hosil bo‘lishi aniqlandi.

Olingan shishakristall namunalarning zichligi 2940-3100 kg/m^3, termik chiziqli kengayish koeffisiyenti 53-64 K^{-1}, mexanik egilishga mustahkamlik darajasi 108-120 MPa, mexanik egilishga mustahkamlik darajasi 700-810 MPa, suv yutuvchanligi 0,001-0,009%, sovuqqa bardoshliligi 112-145 sikl bo‘lib, ushbu ko‘rsatkichlar GOST 13996-2019 talablariga mos keldi.

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