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TECHNOLOGY FOR THE NONDESTRUCTIVE REPROCESSING OF SODIUM IODIDE TECHNOGENIC SOLUTIONS INTO A CHARGE FOR SINGLE CRYSTAL GROWTH

Introduction. *The production of NaI-based single crystals results in accumulation of great amount of liquid waste. To bring valuable constituents of this waste back, the NaI technogenic solutions are treated to precipitate iodine that is further used in the synthesis of high-pure NaI. However, the least contaminated part of the waste may be brought back into the main technological process without the intermediary stage of iodine destruction, which allows a considerable cost saving.*

Problem Statement. *There have been no data on the effective purification coefficients for NaI solutions subsequently treated with barium hydroxide, sodium carbonate, and by mass crystallization. Requirements to impurity content, which NaI solutions have to comply with in order to be used in the nondestructive treatment have not been formulated.*

Purpose. *The purpose of this research is to develop a technology for reprocessing NaI technogenic solutions into sodium iodide of high purity without NaI destruction at the intermediate stage.*

Material and Methods. *The materials that have been used for this research are as follows: aqueous solutions of NaI-based crystal production waste, active coal, barium hydroxide, sodium carbonate. The methods that have been employed are the treatment of NaI solutions with barium hydroxide, sodium carbonate, and by mass crystallization.*

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Results. The technology of NaI solution purification by treatment with barium hydroxide and sodium carbonate with further mass crystallization of the purified salt has been developed. This technology is more environment friendly and cheaper than the conventional one that includes obtaining pure iodine. A series of NaI technogenic solutions has been treated in laboratory conditions and on industrial equipment, and the efficiency of their purification by the chemical treatment and mass crystallization has been estimated. The impurity content in the obtained salt and the scintillation parameters of grown NaI : Tl crystals meet the requirements for these products.

Conclusions. The technology has been implemented in the manufacturing process at the pilot plant of the Institute for Scintillation Materials of the NAS of Ukraine. It may be used at other enterprises that deal with alkali metal iodide waste treatment.

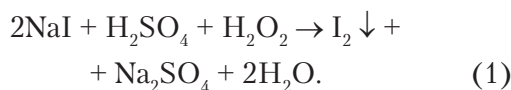
Keywords: sodium iodide, technogenic solutions, nondestructive treatment, and mass crystallization.

Single crystals based on alkali metal iodides is an important constituent of devices for detection of ionizing radiation of various origins, which have a wide range of applications: from science, such as astrophysics or physics of elementary particles, to such vital spheres as safety of nuclear power plants and monitoring of potentially dangerous substances migration. The worldwide demand for such crystals makes up several dozens of tons per a year.

The single crystals growth and the subsequent manufacture of optical elements from the grown crystals are inevitably accompanied with the accumulation of different waste: solidified melt from growth crucibles, wastewaters from washing the equipment etc. Up to half of the initial charge for the crystal growth is wasted.

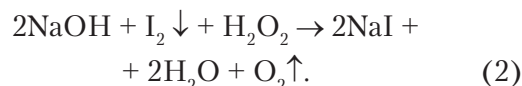
This waste cannot be used again in the crystal production without additional purification, its long-time storage is dangerous for the environment. Therefore, the single crystal manufacturers are interested in the waste reprocessing back into a high-quality charge for looping the production cycle.

The present-day technology for sodium iodide waste reprocessing consists of the dissolution of the waste in water and the subsequent treatment of the obtained solutions with an oxidant in acidic medium. The action of hydrogen peroxide on the waste solution in the presence of sulfuric acid results in iodine precipitation [1]:



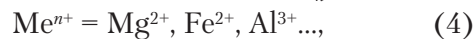
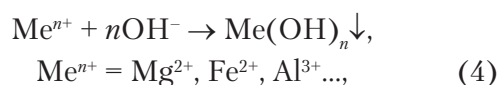
The obtained iodine is purified by sublimation and used for the further synthesis of high-purity sodium iodide, by the so-called the hydroperoxide

method, through adding the iodine and H_2O_2 with 20 per cent excess to NaOH solution:

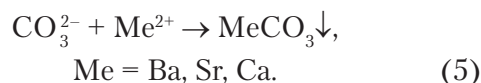


This way of the reprocessing is very lavish from the viewpoint of the required purity chemical reagents which amount is comparable to that of the waste to be reprocessed. The presence of free iodine in the process scheme requires the use of expensive equipment for its capture. Ditto, the iodine precipitation leads to the formation of liquid waste: the contaminated solution of sodium sulfate that needs to be treated at additional costs.

There exists another, nondestructive technique for sodium iodide waste reprocessing, which is similar to the reprocessing of CsI waste. It consists of the sequential treatment of the waste by barium hydroxide, $\text{Ba}(\text{OH})_2$, for the removal of sulfates and heavy metals:



and by sodium carbonate, Na_2CO_3 , for the removal of alkali earth metal impurities:



The consumption of reagents for the said technique is comparable to impurity concentrations, i.e., is relatively small. The further treatment of the purified sodium iodide solution is similar to that used for sodium iodide solutions obtained by the direct synthesis and consists of the purification

tion by crystallization. Therefore, in the case of the hydroperoxide scheme the industrial application of the developed technology provides for either replacing the equipment for salt synthesis with the module for the chemical treatment of waste solution or using both them simultaneously, which reduces the application costs.

However, not all the NaI technogenic solutions can be reprocessed because of the difficulties associated with the solution purification from well-soluble substances [2]. In addition, there have been no available data on the purification efficiency of reactions (3–5) or mass crystallization of NaI solutions.

The purpose of this research is to develop a technology for NaI technogenic solutions reprocessing into sodium iodide of high purity, without their destruction at the intermediate stages, which is based on the experimental data on the efficiency of NaI solution purification from impurities.

The NaI technogenic solution (NaI concentration is 28.7 % wt., $\text{pH} \approx 10$, density is $1.285 \text{ g} \cdot \text{cm}^{-3}$) is taken from the pilot plant of the Institute for Scintillation Materials of National Academy of Sciences of Ukraine (ISMA) for the laboratory experiments. The impurity content in dry NaI is as follows (% wt.): K – $6.7 \cdot 10^{-2}$, Rb – $7.6 \cdot 10^{-5}$, Cs – $3.25 \cdot 10^{-3}$, Mg – $2.55 \cdot 10^{-3}$, Ca – $1.36 \cdot 10^{-2}$, Fe – $5.18 \cdot 10^{-4}$, Ni – $2.16 \cdot 10^{-3}$, Cu – $7.4 \cdot 10^{-4}$, Zn – $1.0 \cdot 10^{-4}$, Cr – $9.2 \cdot 10^{-5}$, Tl – $1.23 \cdot 10^{-3}$, SO_4^{2-} – $5.26 \cdot 10^{-1}$. Before the experiments the solution is filtered through the active coal. After this procedure the impurity concentrations do not change, except for Tl one that decreases 50 times.

$\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ and Na_2CO_3 (both chemically pure) are used for the solution treatment. The solutions of these substances are prepared with the use of distilled water.

In the laboratory conditions, the chemically treated solutions are crystallized in glass-carbon vessels. The NaI concentration is estimated on the basis of the mass of evaporated water. The samples to be analyzed are solutions whose concentrations are determined by density measurements [3].

The conditions of the crystallization processes are chosen given NaI – water phase diagram [4]: anhydrous NaI is formed from the solutions at a temperature above 70°C , whereas at a lower temperature NaI $\cdot 2\text{H}_2\text{O}$ crystallizes.

The first and the second crystallizations are performed by cooling the NaI solutions with the salt concentration of 73 mas. % wt. from $80\text{--}100^\circ\text{C}$ to room temperature (*rt*), which results in the deposition of NaI $\cdot 2\text{H}_2\text{O}$ crystals. These conditions provide the most effective purification from the isomorphic impurities since KI, RbI, and CsI do not form hydrates and remain into liquid phase.

In the third crystallization, the solution is evaporated up to the pulp formation and cooled to a temperature of, at least, 70°C . Then wet anhydrous NaI is separated from the solution. At this stage, there is no essential purification from K, Rb, and Cs, but the formation of NaI with minimal amount of water is necessary for the following sublimation vacuum drying of the salt.

The nondestructive purification technology has been tested with the use of the equipment made of BT-01 titanium. The detailed description of the crystallization purification can be found in [5, 6]. The samples of single crystals are grown in the pilot plant of ISMA.

The elementary separation of impurities from the main substance with the use of the separation element (SE) has been described in [2]. In the initial solution that enters the SE (stage ‘*i*’) the concentration of impurities is x_{i-1} . Two fractions are formed at the output of SE: the product of purification with an impurity concentration of x_i and the mother solution.

The efficiency of SE is characterized by the effective purification coefficients. In this research we have used efficient purification coefficient β that is the concentration of impurity in the product of purification divided by the concentration of impurity in the initial solution. It shows an increase in the impurity concentration after the *i*-th stage:

$$\beta = x_i / x_{i-1}. \quad (6)$$

If impurity concentration decreases as a result of the purification, then $\beta < 1$. If $\beta > 1$, then the product of purification becomes even more contaminated with the corresponding impurity.

The total efficiency of several (n) stages is characterized by β_n coefficient:

$$\beta_n = x_n / x_{i-1}. \tag{7}$$

1. Estimate of purification efficiency of NaI technogenic solutions under laboratory conditions

Two schemes of the chemical treatment under the laboratory conditions have been studied.

According to scheme 1, the solution is filtered after each chemical treatment stage and then is purified by the mass crystallization. The scheme

can be described by the sequence (the concentrations and purification coefficients are designated in the brackets): “filtering through active coal” (c_{ac}, β_{ac}) → “treatment with $Ba(OH)_2$ ” (c_{Ba}, β_{Ba}) → → “filtering” → “treatment with Na_2CO_3 ” (c_{CO_3}, β_{CO_3}) → “filtering (β_{Ba+CO_3})” → “mass crystallization.” So, there are the three mass crystallizations with the cooling of solution to rt ($c_{rt,I} + \beta_{rt,I}; c_{rt,II} + \beta_{rt,II}; c_{rt,III} + \beta_{rt,III}$) and the “hot” crystallization of anhydrous NaI ($c_{hot} + \beta_{hot}$).

In the contrast to the previous one, scheme 2 includes a stage where the chemical treatment operations are combined, which allows skipping out the intermediate filtering of $Ba(OH)_2$ -treated solution. The corresponding sequence is: “filtering through active coal” → “treatment with

Table 1. The Effective Coefficients of NaI Technogenic Solution Purification from Impurities at Separate Stages of the Nondestructive Reprocessing and Their Average Values

Parameter	Impurity, concentration, mas. %, β								
	K	Rb	Cs	Mg	Ca	Zn	Cu	Tl	SO_4^{2-}
c_0	$6.7 \cdot 10^{-2}$	$7.6 \cdot 10^{-5}$	$3.3 \cdot 10^{-3}$	$2.5 \cdot 10^{-3}$	$1.4 \cdot 10^{-2}$	$1.0 \cdot 10^{-4}$	$7.4 \cdot 10^{-4}$	$1.2 \cdot 10^{-3}$	$5.3 \cdot 10^{-1}$
c_{ac}	$7.3 \cdot 10^{-2}$	$8.3 \cdot 10^{-5}$	$3.5 \cdot 10^{-3}$	$2.7 \cdot 10^{-3}$	$1.4 \cdot 10^{-2}$	$1.0 \cdot 10^{-4}$	$6.2 \cdot 10^{-4}$	$1.2 \cdot 10^{-3}$	$5.3 \cdot 10^{-1}$
β_{ac}	1.09	1.09	1.09	1.05	1.05	1.02	0.84	1.00	
c_{Ba}	$7.8 \cdot 10^{-2}$	$7.4 \cdot 10^{-5}$	$4.0 \cdot 10^{-3}$	$8.5 \cdot 10^{-5}$	$1.0 \cdot 10^{-2}$	$1.9 \cdot 10^{-5}$	$5.3 \cdot 10^{-4}$	$1.3 \cdot 10^{-5}$	
β_{Ba}	1.07	0.90	1.13	0.03	0.72	0.18	0.85		
c_{CO_3}	$7.6 \cdot 10^{-2}$	$7.5 \cdot 10^{-5}$	$3.9 \cdot 10^{-3}$	$2.0 \cdot 10^{-5}$	$9.5 \cdot 10^{-3}$	$2.0 \cdot 10^{-5}$	$5.3 \cdot 10^{-4}$	$1.2 \cdot 10^{-5}$	$6.4 \cdot 10^{-2}$
β_{CO_3}	0.98	1.01	0.97	0.23	0.92	1.07	1.01	0.94	
$c_{rt,I}$	$4.8 \cdot 10^{-2}$	$3.5 \cdot 10^{-5}$	$3.1 \cdot 10^{-3}$	$1.4 \cdot 10^{-5}$	$5.7 \cdot 10^{-3}$	$1.8 \cdot 10^{-5}$	$3.2 \cdot 10^{-4}$		$8.0 \cdot 10^{-3}$
$\beta_{rt,I}$	0.63	0.47	0.81	0.70	0.60	0.88	0.61		
$c_{rt,II}$	$3.2 \cdot 10^{-2}$	$2.1 \cdot 10^{-5}$	$2.2 \cdot 10^{-3}$	$1.8 \cdot 10^{-5}$	$4.4 \cdot 10^{-3}$	$1.1 \cdot 10^{-5}$	$2.1 \cdot 10^{-4}$		
$\beta_{rt,II}$	0.67	0.60	0.72	1.25	0.77	0.60	0.65		
$c_{rt,III}$	$1.4 \cdot 10^{-2}$	$1.3 \cdot 10^{-5}$	$1.3 \cdot 10^{-3}$	$1.6 \cdot 10^{-5}$	$2.3 \cdot 10^{-3}$	$7.0 \cdot 10^{-6}$	$8.8 \cdot 10^{-5}$		
$\beta_{rt,III}$	0.44	0.64	0.59	0.90	0.53	0.67	0.42		
c_{hot}	$1.2 \cdot 10^{-2}$	$9.6 \cdot 10^{-6}$	$8.6 \cdot 10^{-4}$	$1.6 \cdot 10^{-5}$	$2.8 \cdot 10^{-3}$	$5.3 \cdot 10^{-6}$	$7.0 \cdot 10^{-5}$		
β_{hot}	0.82	0.71	0.64	1.00	1.19	0.75	0.80		
β_t	0.18	0.13	0.26	0.01	0.20	0.05	0.10	0.01	0.02
$1/\beta_{t,1}$	5.67	7.88	3.79	161.65	4.96	19.09	10.52	98.41	>66
$1/\beta_{t,2}$	6.91	5.88	3.55	166.90	5.48	7.12	19.62	114.57	>12
$1/\beta_{t,1}$	6	7	3.7	164	5	13	15	>100	>39

Ba(OH)₂ and Na₂CO₃ in the same reactor” → “filtering” → “mass crystallization” (the two stages with the cooling of solution to *rt* and the “hot” crystallization). This scheme is attractive in terms of manufacturability because the filtering is made only once, which makes additional vessels and reactors for solution storage unnecessary. The solution to be filtered is alkaline, pH = 11–12, therefore, it destructs the filter material. Using a single filtering stage one can avoid additional contamination of the solution with impurities originating from the filter. The use of this technique allows saving time, materials, and labor inputs. This procedure should be suitable in terms of manufacturability, but needs to be substantiated from the viewpoint of physical chemistry.

The addition of Na₂CO₃ to Ba(OH)₂-treated solution does not change the pH values (the initial pH of Na₂CO₃ solutions ranges within 11–12) and thus does not affect the precipitation of heavy metal hydroxides. Since the solubility of MgCO₃ (730 mg · dm⁻³ ≅ 8,7 · 10⁻³ mol · dm⁻³ [3]) and CaCO₃ (14 mg · dm⁻³ ≅ 1,4 · 10⁻⁴ mol · dm⁻³ [7]) in water exceeds that of BaCO₃ (24 mg · dm⁻³ ≅ 1,2 · 10⁻⁴ mol · dm⁻³ [8]), the Ca²⁺ and Mg²⁺ impurities do not precipitate; so, the addition of Na₂CO₃ provides just the removal of Ba²⁺ excess from the solution.

The results that shows the efficiency of NaI technogenic solution purification at different stages of scheme 1 are presented in Table 1. Table 1 also contains the total purification parameters of schemes 1 and 2 (1/β_{t,1} and 1/β_{t,2} coefficients show purification multiplicity for the whole purification cycles). Their analysis has demonstrated that the above physicochemical predictions are quite true and the proposed purification procedure is effective for removal of Mg²⁺ impurity (it precipitates at the stage of treatment with barium hydroxide). The Tl impurity is easily removed by filtering through active coal. As for the Fe, Ni, and Cr impurities, their concentration in the salt is reduced practically down to the requirements of specifications [9] (% wt.: from 5.18 · 10⁻⁴ to 4.46 · 10⁻⁴ for Fe, from 2.16 · 10⁻³ to 1.84 · 10⁻⁴ for Ni, and from 9 · 10⁻⁵ to 4 · 10⁻⁵ for Cr) due to the

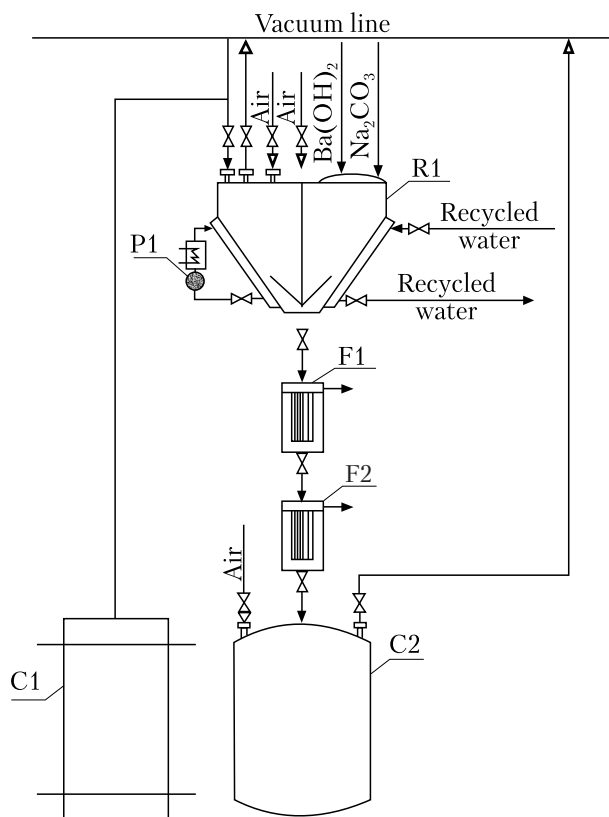


Fig. 1. The flowchart of the module for the purification of NaI technogenic solutions: C1 – transport capacity; C2 – collecting capacity; R1 – reactor; P1 – water-cycle vacuum pump; P2 – circulation pump; F1, F2 – polypropylene cartridge filter

fact that the pH value of initial solution (10) provides the complete precipitation of their hydroxides and one cannot expect any considerable decrease in the concentration of these elements at the chemical treatment stages.

The NaI crystallization processes have shown a low purifying efficiency for removal of Ca, Mg, and alkali metals, $1/\beta_t \approx 5$. Since these impurities originate from tap water, the solutions prepared with its use are not suitable for obtaining high-pure NaI for the nondestructive purification technology.

The purification of sodium iodide from cesium impurities is rather hard, while the removal of potassium and rubidium is somewhat easier.

The low efficiency of aqueous NaI solution purification from impurities is explained by a very

high solubility of sodium iodide in water (~60% wt., at room temperature). The final “hot” crystallization stage is the least efficient among the crystallization stages since the formed anhydrous NaI is isomorphic to the corresponding compounds of K, Rb, and Cs.

Given the values of purification coefficients, we may formulate the following requirements for the maximum excess of impurity content in NaI technogenic solutions over the requirements [9] for the reprocessing of these solutions by the non-destructive method: 20–30 times (Cu and Pb), 10–20 times (Mn, Co, Ni), 2–3 times (Fe, Cr, and Al), 5 times (Ca, K), 150 times for Mg, 30 times for sulfates, and 100 times for Tl.

2. The process flowchart and the obtained results of the purification

For practical application of the developed technology the module for the deep purification of NaI technogenic solution has been assembled and tested in the line of charge production for the growth of sodium and cesium iodide single crystals (its flowchart is presented in Fig. 1).

The process is realized according to regulations No 04:2021 for the deep purification of sodium iodide solutions (developed at ISMA) and includes the following stages: the download of initial NaI solution into reactor, its sequential treatment with barium hydroxide and sodium carbonate and filtering of the treated solution.

Table 2. The Hydroperoxide (production-run No. 8) and Nondestructively Obtained NaI (No. 9–11) Impurity Content and the Requirements for High-Pure Sodium Iodide [9]

	c · 10 ⁶ , % wt.											
	Cu	Pb	Fe	Al	Cr	Mn	Ni	Ti	K	Mg	Ca	SO ₄ ²⁻
c ₀	30	20	60	50	<30	<10	50	40	100	200	70	5000
est**	75	75*	60	50*	25	20*	80	—	130	8214	55	20000
±	+	+	+	+	±	+	+	?	+	+	—	+
No. 8	5	<5	50	<50	<30	<10	<30	<30	22	<10	40	<500
No. 9	6	5	20	<50	<30	<10	<30	<30	12	<10	20	500
No. 10	5	<5	40	<50	<30	<10	<30	<30	12	70	15	<500
No. 11	6	5	20	50	<30	<10	<30	<20	22	10	30	<500
[9]	5	5	40	20	10	2	8	70	20	50	10	500

Note. “±” — compliance with the purity requirements: “+” — ‘meets’; “—” — ‘does not meet’; “?” — ‘unknown’; * — estimated based on the similarity of properties in sequences: CuI-PbI₂, Cr³⁺-Al³⁺, Ni²⁺-Mn²⁺ est; ** — the ceiling impurity concentration allowed for the nondestructive reprocessing has been estimated.

Table 3. The Operating Parameters of NaI : Tl Single Crystals Grown from the Charge Obtained by the Hydroperoxide Technology (No. 8) and by the Proposed Nondestructive Technology (No. 11)

Production-run	Detector No.	The sample position in the crystal boule (height)	Activator concentration, mass per cent	L*	R**
No. 8	391-P3-C	Medium	0.077	4.2	6.0
No. 8	391-P3-H	Bottom	0.093	4.3	6.1
No. 11	394-P3-B	Top	0.084	4.3	6.1
No. 11	394-P3-C	Medium	0.077	4.3	6.2

Note. * — the light yield, arbitrary units; ** — energy resolution, %.

The treated solution is purified by crystallization: at the first and the second crystallizations the solution is evaporated up to NaI content of 73–75% wt. in vacuum evaporation apparatus, at a temperature of 60–80 °C. Then the solution is immersed into the crystallization vessel by gravity flow and cooled down to 20–25 °C. The crystals are separated from the liquid in Nutsche filter and are fed to the next crystallization stage.

To perform the third crystallization, NaI · 2H₂O crystals are dissolved in deionized water and the solution is evaporated at 80–90 °C to the pulp formation (mass fraction of NaI is ca. 0.9). Wet NaI crystals are separated from the solution in the Nutsche filter heated to ca. 75 °C. The resulting salt is dried under vacuum with a temperature increase to 180–200 °C, for 6–7 h.

On the basis of these experiments, only the NaI technogenic solutions obtained with the use of pure (purified by electroosmosis) water are chosen for the nondestructive purification. The solutions made with tap water are not used for the technology.

The NaI solutions undergo chemical treatment and are purified by the mass crystallization. The results of the impurity analysis of the obtained NaI are presented in Table 2.

The presented data have shown that the quality of NaI salt obtained from the technogenic solutions with the use of the nondestructive technology is quite good and the contents of common impurities meet the present-day requirements. Nevertheless, the problem of calcium removal has not been completely solved yet.

To check the suitability of the obtained salt (No. 11) for single crystal growth, it has been used

for the growth of NaI : Tl single crystals. The salt of product-run No. 8 is taken as a reference charge. The light yield and the energy resolution have been determined with the use of the measuring equipment of the ISMA pilot plant. The results are given in Table 3.

The presented data have shown that the operating parameters of the crystals grown from the charge obtained with the use of the developed technology are practically as good as those of the crystals grown from the synthesized charge.

So, the regularities of the purification of sodium iodide technogenic solutions from different impurities at different stages of the nondestructive reprocessing have been determined. It has been found that the NaI technogenic solutions are suitable for nondestructive treatment if the content of K, Rb, Ca, and Mg in them is at most 5 times higher than in the extra pure salt.

The technology of NaI solution purification by treatment with barium hydroxide and sodium carbonate with the mass crystallization of the purified salt has been developed. This technology is more environment friendly and cheaper than the conventional one that includes obtaining pure iodine. The technology has been applied at the pilot plant of the Institute for Scintillation Materials of the National Academy of Sciences of Ukraine.

The impurity concentrations in the sodium iodide obtained from the technogenic solutions prepared with the use of purified water meet the requirements of the corresponding specifications. The NaI-based scintillation crystals grown from the charge obtained according to the proposed nondestructive technology have satisfactory operating parameters.

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ТЕХНОЛОГІЯ НЕРУЙНІВНОЇ ПЕРЕРОБКИ ТЕХНОГЕННИХ РОЗЧИНІВ ЙОДИДУ НАТРІУ У СИРОВИНУ ДЛЯ ВИРОЩУВАННЯ МОНОКРИСТАЛІВ

Вступ. Виробництво монокристалів на основі йодиду натрію супроводжується накопиченням значної кількості рідких залишків-відходів. Для повернення цінних складових з них у виробничий процес техногенні розчини NaI окислюють для осадження йоду, який спрямовують на синтез йодиду натрію високої чистоти. Однак, частину залишків, найменш забруднену домішками, може бути повернуто в основний технологічний цикл без проміжного виділення йоду, що значно зменшить вартість процесу переробки.

Проблематика. Дотепер не визначено ефективні коефіцієнти очищення розчинів NaI від домішок при обробці гідроксидом барію, карбонатом натрію та в процесі масової кристалізації. Немає даних щодо граничного вмісту домішок у залишках, які можуть бути використані у технологічному процесі неруйнівної переробки.

Мета. Розробка технології переробки розчинів йодиду натрію у високочисту сіль без виділення йоду на проміжних стадіях.

Матеріали й методи. Матеріали: водні розчини залишків кристалів на основі NaI, активне вугілля, гідроксид барію, карбонат натрію; методи: обробка розчинів гідроксидом барію і карбонатом натрію з наступною масовою кристалізацією йодиду натрію.

Результати. Розроблено технологію очищення розчинів NaI гідроксидом барію і карбонатом натрію з наступною масовою кристалізацією солі, яка є більш екологічно безпечною і менш витратною, порівняно з традиційною. Процеси очищення техногенних розчинів йодиду натрію відпрацьовані в лабораторних умовах і на промисловому обладнанні. Оцінено ефективні коефіцієнти очищення при хімічній обробці й масовій кристалізації йодиду натрію. Вміст домішок у солі NaI і сцинтиляційні параметри отриманих з неї монокристалів NaI : Tl задовольняють загальні вимоги до цих продуктів.

Висновки. Технологію впроваджено на дослідному виробництві Інституту сцинтиляційних матеріалів НАН України. Її може бути застосовано на інших виробництвах, які переробляють залишки йодидів лужних металів.

Ключові слова: йодид натрію, техногенні розчини, неруйнівна переробка, масова кристалізація.