ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТА

ҚАЗАҚСТАН ҒЫЛЫМЫ МЕН ТЕХНИКАСЫ

2001 ЖЫЛДАН БАСТАП ШЫҒАДЫ

TORAIGHYROV UNIVERSITY

НАУКА И ТЕХНИКА КАЗАХСТАНА

ИЗДАЕТСЯ С 2001 ГОДА

ISSN 2788-8770

№ 4 (2023)

ПАВЛОДАР

НАУЧНЫЙ ЖУРНАЛ
ТОРАЙГЫРОВ УНИВЕРСИТЕТ
выходит 1 раз в квартал

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агенства и сетевого издания
№ KZ51VPY00036165

выдано
Министерством информации и общественного развития
Республики Казахстан

Тематическая направленность
Публикация научных исследований по широкому спектру проблем
в области металлургии, машиностроения, транспорта, строительства,
химической и нефтегазовой инженерии, производства продуктов питания

Подписной индекс – 76129

https://doi.org/10.48081/PWGH3542

Импакт-фактор РИНЦ – 0,210

Импакт-фактор КазБЦ – 0,406

SRSTI 53.39.31; 53.49.15; 53.39.01

https://doi.org/10.48081/CBHA5682

K. Tuyskhan[1], G. E. Akhmetova[2], G. A. Ulyeva[3]
[1,2]Karaganda Industrial University, Republic of Kazakhstan, Temirtau;
[3]JSC «ArcelorMittal Temirtau», Republic of Kazakhstan, Temirtau
*e-mail: kura_tuyskhan@mail.ru

ANALYSIS OF THE STRUCTURE OF INDUSTRIAL WASTE USED TO CREATE NEW COMPOSITE MATERIALS

During the production of silicon, a significant amount of waste is generated, namely micro- and nanosilica. Micro- and nanosilica, with its properties and structure, immediately interested scientists in many countries from the point of view of processing this material into a new product with unique functional properties. The article presents the results of studies of waste from various industries – microsilica, as a waste of silicon production, zinc ash – a waste of the hot-dip galvanizing process, and abrasive powder – a waste of metal machining. To study waste from various industries, the authors used the method of electron microscopy as the simplest and fastest way to transmit information about the microstructure, elemental composition and grain size distribution. A comparative analysis of the microstructures and properties of these materials was carried out in order to better understand the nature and predict the possibility of their further use as initial components for the production of new composite materials.

Keywords: microsilica, zinc ash, microstructure, waste disposal, composite material, properties of new materials.

Introduction

Characteristics of the objects of study. In the works [1], it was indicated that microsilica is one of the most famous pozzolanic substances to date, which is actively used in the construction industry; It is a fine gray dust with amorphous properties. It is extracted from the exhaust gases of furnaces during the smelting of metallurgical silicon and ferrosilicon. Microsilica, in contrast to traditional high-silica raw materials, such as quartz sand, is a light, finely dispersed material consisting of the smallest spheres of amorphous silica with particle sizes of 0.01–0.07 μm [2].

Microsilica consists of the smallest conglomerates of dust particles with the following diameter: – in an uncompacted state: 5 mm – 0%. The angle of repose of compacted silica fume is 600. According to the results of studies by Russian and foreign companies, the chemical composition of microsilica is as follows: SiO_2: 90–92 %; Al_2O_3: 0.6–0.8%; Fe_2O_3: 0.4–0.7 %; CaO: 0.4–0.9 %; MgO: 0.8–1.0 %; Na_2O: 0.6–0.8%; K_2O: 1.2–1.4 %; C: 0.9–1.2 %; S: 0.2–0.3 %.

At the moment, the fields of application of microsilica as a hardening modifier in the production of concrete [3, 4], as well as in the production of dry building mixes, foam concrete, cement, ceramics, facing slabs, paving slabs, curbs, tiles, refractory masses, rubber, coatings are known.

Zinc ash (zinc slag) is the residue that forms in the galvanizing bath after hot dip galvanization of steel. Table 1 shows the classic chemical composition of zinc ash.

Table 1 – Chemical composition of zinc burns

Element name	Zn	O	C	Si	P	S	Cl
Element content, [%]	65,66	22,22	6,68	0,64	0,05	0,10	2,80
Element name	K	Ca	Mn	Fe	Cu	Al	Pb
Element content, [%]	0,10	0,10	0,10	0,27	0,46	0,63	0,16

After galvanization, zinc ash is removed after each galvanizing cycle. It is known that zinc ashes in the future in the form of powder or wire can be used in zinc sputtering in order to obtain a protective layer to increase the service life of surfaces.

Cutting disc waste is abrasive particles lagging behind cutting or grinding wheels during the cutting process, consisting of electrocorundum. Table 2 shows the classical chemical composition of abrasive dust [5]. The composition of abrasive dust can be simpler and consist of 80–90 % silicon dioxide and 20–10 % iron.

Table 2 – Chemical composition of abrasive dust

Component name	Fe	P	As	S	Cu	Si
Content, [%]	29,6	0,0075	0,000003	0,009	0,045	0,009
Component name	Mn	Ni	Cr	FeO	Al_2O_3	C
Content, [%]	0,135	0,03	0,03	21,1501	48,9	0,03

Scrap metal recycling is of great economic and environmental importance. Taking into account the modern industrial development of the world and the volumes of metal involved in the sphere of industrial use, it becomes clear that the volume of metal and the amount of scrap metal constantly entering the scrap is colossal. In many countries of the world, technologies for the processing of metal production waste have existed for more than a hundred years.

The main incentives for the processing of metal production waste:

– reducing the load on metal deposits, which are currently heavily depleted;

– improvement of the ecological situation;

– reduction of fuel volumes for obtaining the most important metals [6].

And the development of nanotechnology and the widespread use of nanomaterials in various industries (electronics, medicine, plastic, ceramic, polymeric materials, pigments and paint) allows us to count on their successful application in the construction industry [7].

Material and research methods

1) zinc ash.

Closed-loop technology in which zinc ash from hot dip galvanization is recycled and sprayed thinly onto steel products. This sustainable solution extends the life of the surfaces by converting zinc ash into a valuable raw material.

When galvanizing every 1000 kg of steel products, 10.1 kg of hotzinc and 9.1 kg of zinc ash are formed, which can be used in the manufacture of mixtures for applying zinc coatings. RUE «Rechitsa hardware plant» (Belarus) produces 13 tons of hardzinc and about 8 tons of pussier per month. About 120 tons of zinc-containing wastes have accumulated at the KONUS RDPP (Belarus). According to the authors of [7], the development of a competitive galvanizing technology based on mixtures obtained from zinc-containing waste will improve the quality of the coating and ensure the processing of many tons of galvanizing waste.

The paper [8] considers the technology of zinc depletion in the composition of ash, which is one of the main wastes of hot-dip galvanizing of metal products.

2) microsilica.

Currently, in addition to the natural forms of silicon dioxide, there are many synthetic types. Amorphous (non-crystalline) silicon dioxide with a high specific surface area is almost never found in nature in its pure form. Amorphous silicas, including nanosilicas obtained from hydrothermal solutions, are finding new applications in the construction industry. Thus, in [9, 10], the authors present a technology for the use of reactive SiO2 nanoparticles as an additive for strengthening concrete instead of microsilica. The results showed an increased strength of fine-grained concrete when using nanosilica, which is explained by its smaller size, respectively, higher specific surface area of the particles.

3) abrasive cutting discs.

Abrasive materials come in many varieties, which is one of the reasons why so much attention is paid to the disposal of abrasive materials. Abrasive materials are divided by chemical composition, degree of hardness, size of the grinding grain. In our time, these materials are produced and mined mainly synthetically, whereas in the past natural abrasive materials were widely used. Disposal of abrasive materials can be divided into two parts. This is the disposal of abrasive materials in the form of dust and powder and the disposal of abrasive materials in the form of used abrasive wheels and scrap from abrasive wheels. Abrasives are very hard materials used on a variety of surfaces. Used for polishing, grinding, cutting, honing, superfinishing both metal and other materials. The first type, in the form of powder and dust, is precisely what is formed after all these types of processing. Disposal of abrasive materials is a necessary measure resorted to by various factories and plants where all the treatments described above take place [11].

The importance of abrasive powder in the field of abrasive blasting is constantly increasing and today, it occupies a very high place. Leading companies in the field of ACB use exactly abrasive powder - cooper slag, which is increasingly replacing other types of abrasive materials and, above all, quartz sand (already banned for use by dry cleaning). The consumption of abrasive powder is only increasing every year. Thus, in 2017 alone, the Karabash Abrasive Plant doubled its shipment compared to 2016 [12].

Scrap abrasive wheels represent a specific type of waste. Undoubtedly, even used grinding materials are of interest to a certain category of entrepreneurs. A significant share of the demand for abrasive waste falls on discs with a ceramic or bakelite base, where the technology for separating grinding granules is well developed. Similar requirements for a certain type of bond are often associated with the technology for extracting grinding grain from waste products. For example, scrap abrasive wheels are often recycled by annealing or two-stage leaching, which effectively removes the bakelite bond [13].

The Karabash Abrasive Plant LLC [12] offers a technology for using abrasive waste for sandblasting, while only the fractional composition changes, while all other properties remain the same. This method allows several times to reduce the cost of disposal of abrasive powder waste, since there is no need to transport it to specially prepared sites for the disposal of hazardous waste.

The paper [14] provides a technology for processing abrasive materials when extracting conditioned abrasive materials, magnetic and non-magnetic metals, and binders from abrasive production waste in order to increase their degree of extraction and reduce processing costs. The method includes magnetic and electrostatic separation at an electric field strength of 0.8–5.0 kV/cm and classification by grain composition.

Thus, as can be seen from the above literature review of the current state of the problem of utilization and use of finely dispersed waste, the authors of this work see great prospects for using production waste, taking into account their properties, structure, and fineness, to obtain new composite nanomaterials.

Microsilica powder weighing 100 g was divided into fractions of 45–63 and less than 45 өm on an analytical laboratory sieving machine «Retsch AS200 control» [15].

Then, microsilica powder with fractions of 45–63 and less than 45 μm was ground in a high-speed ball mill by Emax in order to reach the nanoscale level. Grinding speed 1000 rpm, duration 1 hour.

The cutting disc waste and zinc ash were ground in a laboratory ball mill with a duration of 20 min. Then the crushed powder of these materials was separated into a fraction of less than 45 өm on an analytical laboratory sieving machine «Retsch AS200 control».

Results and discussion

Using a scanning electron microscope, the particles of the resulting sieved powders of the starting materials were measured (figure 1).

Table 3 shows the average particle sizes of the powdered materials.

Table 3 – Particle size of powder materials

Parameter	Values			
	SiO_2, >45 μm	SiO_2, 45-63 μm	ZnO	disk waste
Average particle size, [nm^2]	38300	175743	251853	166465
Maximum value, [nm^2]	246076	371810	583748	219100
Minimum value, [nm^2]	20741	157090	107219	82973
Takeoff run, [nm^2]	225335	214720	476529	136127

As can be seen from the figure and table, the particle size of the components used in the creation of new materials reaches the nanolevel. The microsilica particles of fraction >45 μm (38300 nm^2) have the smallest sizes, and zinc ash (251853 nm^2) have the largest values. The figure shows that the particles of the studied samples have different geometric shapes and their bond nature. So, microsilica of both fractions has a pronounced spherical shape, the particles themselves form conglomerates («clouds») of a dense structure, located separately from each other, consisting of many crystallites of various sizes closely spaced to each other. Such a structure suggests that such a substance has increased strength properties.

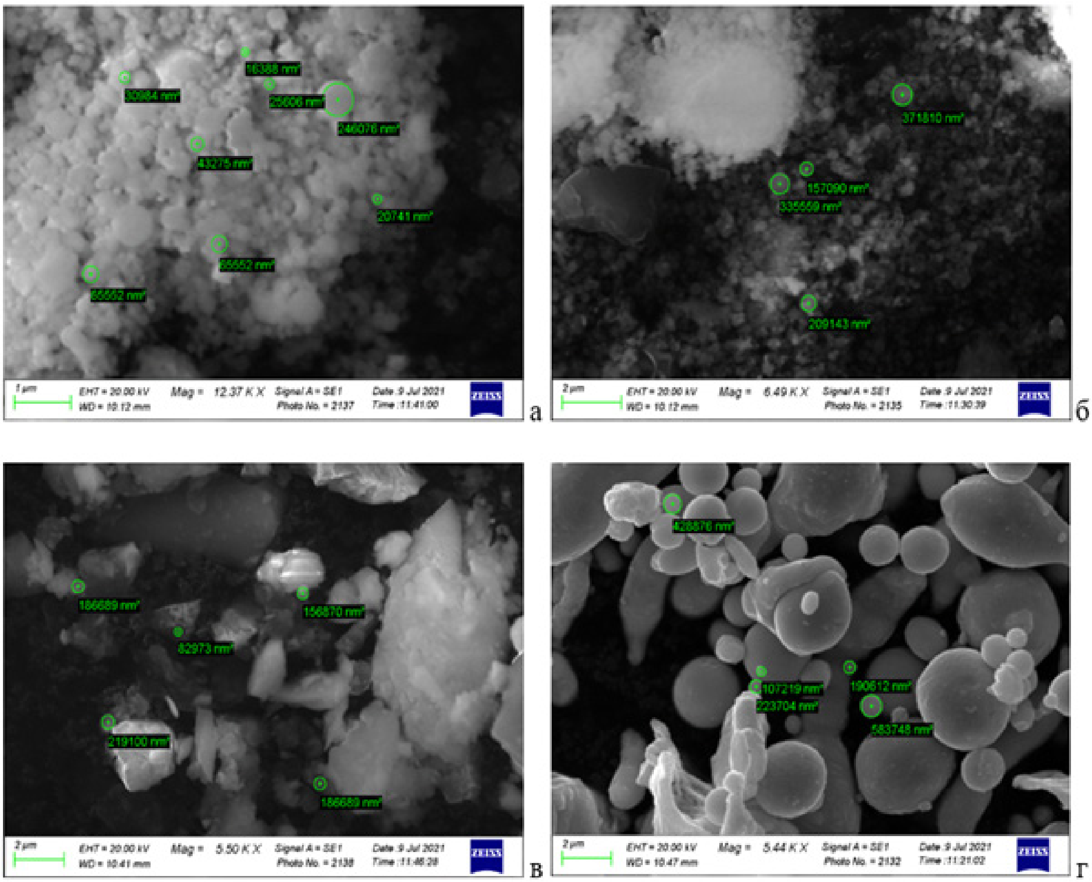

Figure 1 – Microstructure of production waste: a – microsilica >45 өm, 12370x; b - microsilica 45–63 өm, 6500x; c – cutting disc waste, 5500x; d – zinc ash, 5440x

The waste of the cutting disc has crystallites of irregular geometrical, fragmentary shape with sharp edges of various sizes and smooth walls. This suggests the presence of a characteristic increased hardness combined with some brittleness of the ground material. Also, a characteristic feature is the disparate relative position of the particles, which indicates weak cohesive forces.

Waste particles from zinc ash are characterized by a distinct drop-shaped and/or rounded structure. The particles have even smooth walls and are located close enough to each other, which indicates an intermediate position of the specified material in terms of strength properties in comparison with microsilica and cutting disc abrasive.

Determining the shape of particles seems to be one of the simplest and most accessible characteristics of a material to a researcher. The shape of the particles significantly affects the technological properties of the material and through them on the density, strength and uniformity of the properties of the workpiece obtained from it. For example, the most durable products give particles of a dendritic shape, since in this case, along with cohesive forces, there are purely mechanical causes: jamming of particles, interweaving of protrusions and branches. The surface roughness of the particles increases their excess energy, which subsequently accelerates the formation of the properties of powder nanoproducts during sintering [16].

Conclusion

Thus, as can be seen from the nature of the mutual arrangement and geometry of the structures of the powders under study, it is possible to grind microsilica to the smallest particle sizes (to individual spheres), which is evidence of the greatest promise of this material in the creation of new materials, including nanocomposites.

REFERENCES

1 **Akhmetova, G. E., Ulyeva G. A., Tuyskhan K.** On the Issue of Alloying and Modification of Alloys: Using the Waste Products for Creation of Novel Materials // Progress in Physics of Metals. – 2021. – 22. – № 2. – P. 271–289.

2 **Антипина, С. А., Дроздов, Л. В.** Исследование поведения микрокремнезема при термической обработке // Труды Х Международного симпозиума имени академика М.А. Усова студентов и молодых учёных. – 2010. – Сек.15. – С. 1–2.

3 **Nandhini, K., Karthikeyan, J.** A review on sustainable production of self-compacting concrete utilizing industrial by-products as cementitious materials // Innov. Infrastruct. Solut. – 2022. – 7. – 199.

4 **Polonina, E. N., Leonovich, S. N., Khroustalev, B. M., Sadovskaya, E. A., Budrevich, N. A.** Cement-Based Materials Modified with Nanoscale Additives // Science and technology. – 2021. – Vol. 20. – № 3. – P. 189–194.

5 Абразивная пыль и порошок от шлифования черных металлов // [Электронный ресурс]. – URL:https://eco-profi.info/index.php/othod/sostav/66-3140030011004.html (Дата обращения 05.02.2023).

6 **Константинов, В. М.** Анализ рынка цинка и цинковых отходов для получения антикоррозионных покрытий / Константинов В.М., Гегеня Д. В., Богданчик М. И. // Металлургия: республиканский межведомственный сборник научных трудов. – Минск : БНТУ. – 2015. – Вып. 36 – С. 272–283.

7 **Потапов, В. В., Горев, Д. С., Туманов, А. В., Кашутин, А. Н., Горева, Т. С.** Получение комплексной добавки для повышения прочности бетона на основе нанодисперсного диоксида кремния гидротермальных растворов // Фундаментальные исследования. – 2012. – № 9. – С. 404–409.

8 **Крестьянинов, А. Т., Краюхина, С. А., Тимофеев, К. Л., Мысляев, А. Д., Бердышев, Д. А., Кочин, В. А.** Патент «Способ извлечения цинка из изгари цинка в процессе цинкования». Дата опубликования 16.04.2018. Бюл. №11.

9 **Потапов, В. В., Горев, Д. С.** Сравнительные результаты повышения прочности бетона вводом нанокремнезема и микрокремнезема // Современные наукоемкие технологии. – 2018. – № 9. – С. 98–102.

10 **Потапов, В., Кашутин, А., Сердан, А., Горбач, В., Шалаев, К.** Нанодисперсный диоксид кремния : повышение прочности строительных материалов // Наноиндустрия. – 2012. – № 2 (32). – С. 44–50.

11 Утилизация абразивных отходов // [Электронный ресурс]. – URL:http://eco-spas.ru/utilizatsiya-abrazivnyh-othodov (Дата обращения 05.02.2023).

12 Утилизация отходов использованного абразивного порошка // [Электронный ресурс]. – URL:http://daka1.ru/publikatsii/utilizatsiya-otkhodov-ispolzovannogo-abrazivnogo-poroshka.html (Дата обращения 05.02.2023).

13 Лом абразивных кругов // [Электронный ресурс]. – URL:https://xlom.ru/nemetal-lom/lom-abrazivnyx-krugov-abrazivnyj-lom (Дата обращения 05.02.2023).

14 **Москаленко, О. П., Коренев, С. И., Шинка, В. П., Кацнельсон, Я. Е.** Патент «Способ переработки отходов абразивных материалов». Опубликовано: 02.07.1992.

15 **Akhmetova, G. E., Tuyskhan, K., Ulyeva, G. A., and Reshotkina, E. N.** Development of New Composite Materials Based on 'Metal–Non-Metal' with Improved Functional Properties // Metallofiz. Noveishie Tekhnol. – 2022. – 44, № 9. – P. 1137–1146.

16 **Либенсон, Г. А., Лопатин, В. Ю., Комарницкий, Г. В.** Процессы порошковой металлургии. В 2-х томах. Т. 1. Производство металлических порошков : Учебник для вузов. – М. : «МИСИС», 2001. – 368 с.

REFERENCES

1 **Akhmetova, G. E., Ulyeva, G. A., Tuyskhan, K.** On the Issue of Alloying and Modification of Alloys : Using the Waste Products for Creation of Novel Materials // Progress in Physics of Metals. – 2021. – 22. – №. 2. – P. 271–289.

2 **Antipina, S. A., Drozdov, L. V.** Issledovanie povedeniya mikrokremnezema pri termicheskoj obrabotke [Study of the behavior of microsilica during heat treatment] // Trudy` X Mezhdunarodnogo simpoziuma imeni akademika M. A. Usova studentov i molody`x uchyony`x. – 2010. – Sek. 15. – P. 1–2.

3 **Nandhini K., Karthikeyan J.** A review on sustainable production of self-compacting concrete utilizing industrial by-products as cementitious materials // Innov. Infrastruct. Solut. – 2022. – 7. – 199.

4 **Polonina E. N., Leonovich S. N., Khroustalev B. M., Sadovskaya E .A., Budrevich N. A.** Cement-Based Materials Modified with Nanoscale Additives // Science and technology. – 2021. – Vol. 20, № 3. – P. 189–194.

5 Abrazivnaya py`l` i poroshok ot shlifovaniya cherny`x metallov [Abrasive dust and powder from grinding ferrous metals] // [Electronic resource]. – URL:https://eco-profi.info/index.php/othod/sostav/66-3140030011004.html (Date of application 05.02.2023).

6 **Konstantinov, V. M.** Analiz ry`nka cinka i cinkovy`x otxodov dlya polucheniya antikorrozionny`x pokry`tij [Analysis of the market for zinc and zinc waste for the production of anti-corrosion coatings] / Konstantinov V.M., Gegenya D.V., Bogdanchik

M.I. // Metallurgiya : respublikanskij mezhvedomstvenny`j sbornik nauchny`x trudov. – Minsk: BNTU. - 2015. – Vy`p. 36 – P. 272–283.

7 **Potapov, V. V., Gorev, D. S., Tumanov, A. V., Kashutin, A. N., Goreva T. S.** Poluchenie kompleksnoj dobavki dlya povy`sheniya prochnosti betona na osnove nanodispersnogo dioksida kremniya gidrotermal`ny`x rastvorov [Obtaining a complex additive to increase the strength of concrete based on nanodispersed silicon dioxide hydrothermal solutions] // Fundamental`ny`e issledovaniya. – 2012. – № 9. – P. 404–409.

8 **Krestyaninov, A. T., Krayukhina, S. A., Timofeev, K. L., Myslyaev, A. D., Berdyshev, D. A., Cochin, V. A.** Patent «Sposob izvlecheniya cinka iz izgari cinka v processe cinkovaniya» [Method of extracting zinc from zinc ash in the galvanizing process]. Data opublikovaniya 16.04.2018. Byul. № 11.

9 **Potapov, V. V., Gorev, D. S.** Sravnitel`ny`e rezul`taty` povy`sheniya prochnosti betona vvodom nanokremnezema i mikrokremnezema [Comparative results of increasing the strength of concrete by introducing nanosilica and microsilica] // Sovremenny`e naukoemkie texnologii. – 2018. – № 9. – P. 98–102.

10 **Potapov, V., Kashutin, A., Serdan, A., Gorbach, V., Shalaev, K.** Nanodispersny`j dioksid kremniya : povy`shenie prochnosti stroitel`ny`x materialov [Nanodispersed silicon dioxide : increasing the strength of building materials] // Nanoindustriya. – 2012. – № 2(32). – P. 44–50.

11 Utilizaciya abrazivny`x otxodov [Disposal of abrasive waste] // [Electronic resource]. – URL:http://eco-spas.ru/utilizatsiya-abrazivnyh-othodov (Date of application 05.02.2023).

12 Utilizaciya otxodov ispol`zovannogo abrazivnogo poroshka [Disposal of used abrasive powder] // [Electronic resource]. – URL:http://daka1.ru/publikatsii/utilizatsiya-otkhodov-ispolzovannogo-abrazivnogo-poroshka.html (Date of application 05.02.2023).

13 Lom abrazivny`x krugov [Scrap of abrasive wheels] // [Electronic resource]. – URL:https://xlom.ru/nemetal-lom/lom-abrazivnyx-krugov-abrazivnyj-lom (Date of application 05.02.2023).

14 **Moskalenko, O. P., Korenev, S. I., Shinka, V. P., Katsnelson, Ya. E.** Patent «Sposob pererabotki otxodov abrazivny`x materialov» [Method of recycling waste abrasive materials]. Opublikovano: 02.07.1992.

15 **Akhmetova, G. E., Tuyskhan, K., Ulyeva, G. A., and Reshotkina, E. N.** Development of New Composite Materials Based on ‘Metal–Non-Metal’ with Improved Functional Properties // Metallofiz. Noveishie Tekhnol. – 2022. – 44, № 9. – P. 1137–1146.

16 **Libenson, G. A., Lopatin, V. Yu., Komarnitsky, G. V.** Processy` poroshkovoj metallurgii [Processes of powder metallurgy]. V 2-x tomax. T.1. Proizvodstvo metallicheskix poroshkov: Uchebnik dlya vuzov. – Moscow : «MISIS», 2001. – 368 p.

Accepted for publication on 29.11.23.

***К. Туысхан[1], Г. Е. Ахметова[2], Г. А. Ульева[3]**
[1,2]Қарағанды индустриялық университеті,
Қазақстан Республикасы, Теміртау қ.;
[3]«АрселорМиттал Теміртау» АҚ, Қазақстан Республикасы, Теміртау қ.
Басып шығаруға 29.11.23 қабылданды.

ЖАҢА КОМПОЗИЦИЯЛЫҚ МАТЕРИАЛДАРДЫ ЖАСАУДА ҚОЛДАНЫЛАТЫН ӨНЕРКӘСІПТІК ҚАЛДЫҚТАРДЫҢ ҚҰРЫЛЫМЫН ТАЛДАУ

Кремний өндіру кезінде қалдықтардың едәуір мөлшері, яғни атап айтқанда микро- және наносилика пайда болады. Микро- және наносилика өзінің құрылымы және қасиеттері бойынша көптеген елдердің ғалымдарын осы материалды бірегей функционалдық қасиеттері бар жаңа өнімге қайта өңдеу тұрғысынан бірден қызықтырды. Бұл мақалада әртүрлі салалардағы қалдықтарды зерттеу нәтижелері, яғни микрокремнезем - кремний өндірісінің қалдықтары, мырыш күлі – ыстық мырыштау процесінің қалдықтары және абразивті ұнтақ – металдарды механикалық өңдеу қалдықтары ретінде зерттеулердің нәтижелері келтірілген. Әр түрлі салалардағы қалдықтарды зерттеу үшін авторлар электронды микроскопия әдісін микроқұрылымды, элементтік құрамды және түйір мөлшерін таралу туралы ақпаратты берудің ең оңай және жылдам әдісі ретінде қолданды. Табиғатын тереңірек түсіну және олардан жаңа композициялық материалдарды өндірудің бастапқы компоненттері ретінде одан әрі қолдану мүмкіндігін болжау мақсатында аталған материалдардың микроқұрылымы мен қасиеттеріне салыстырмалы талдау жүргізілді.

Кілтті сөздер: микрокремнезем, микросилика, мырыш күлі, микроқұрылым, қалдықтарды кәдеге жарату, композициялық материал, жаңа материалдардың қасиеттері.

К. Туысхан[1], Г. Е. Ахметова[2], Г. А. Ульева[3]
[1,2]Карагандинский индустриальный университет,
Республика Казахстан, г. Темиртау;
[3]АО«АрселорМиттал Темиртау», Республика Казахстан, г. Темиртау
Принято к изданию 29.11.23.

АНАЛИЗ СТРОЕНИЯ ПРОМЫШЛЕННЫХ ОТХОДОВ, ИСПОЛЬЗУЕМЫХ ПРИ СОЗДАНИИ НОВЫХ КОМПОЗИЦИОННЫХ МАТЕРИАЛОВ

При производстве кремния образуется значительное количество отходов, а именно микро- и наносилика. Микро- и наносилика своими свойствами и структурой сразу заинтересовал ученых многих стран с точки зрения переработки этого материала в новый продукт, обладающий уникальными функциональными свойствами. В статье приведены результаты исследований отходов различных отраслей промышленности – микрокремнезема, как отхода кремниевого производства, изгари цинка – отхода процесса горячего оцинкования и абразивный порошок – отхода механической обработки металлов. Для исследования отходов различных отраслей промышленности авторы использовали метод электронной микроскопии, как наиболее простой и быстрый способ передачи информации о микроструктуре, элементном составе и распределение по размерам зерен. Проведен сравнительный анализ микроструктур и свойств указанных материалов с целью более глубокого понимания природы и прогноза возможности их дальнейшего применения в качестве исходных компонентов для производства новых композиционных материалов.

Ключевые слова: микрокремнезем, микросилика, изгарь цинка, микроструктура, утилизация отходов, композиционный материал, свойства новых материалов.

Теруге 08.12.23 ж. жіберілді. Басуға 29.12.23 ж. қол қойылды.
Электрондық баспа
5,07 Mb RAM
Шартты баспа табағы 17,26 Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген: Е. Е. Калихан
Корректор: А. Р. Омарова

Тапсырыс № 4166

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов көш., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69

e-mail: kereku@tou.edu.kz
nitk.tou.edu.kz