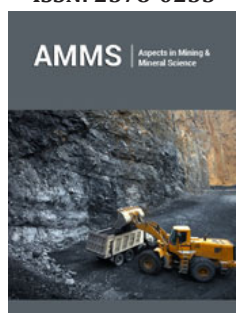


Formation of Rhenium and Tantalum During Electrolysis of Distilled Water Using Tungsten Electrodes and the Expected Isotope Ratio

ISSN: 2578-0255



Kashchenko MP^{1,2}, Pechorsky VI², Kashchenko NM^{1*}, Nikolaeva NV³ and Pushin VG^{1,3}

¹Ural Federal University named after the first President of Russia B N Yeltsin, Russia

²Ural State Forest Engineering University, Russia

³Mikheev Institute of Metal Physics, Ural Branch of RAS, Russia

Abstract

The original installation for plasma electrolysis of water demonstrated, according to [1], an example of the implementation of low-energy nuclear reactions of the synthesis of chemical elements with low erosion of electrodes. That is, the initial material for the formation of chemical elements was water, and the product was a solid fraction in the form of a polymetallic powder.

Keywords: Copper; Chemical elements; Tungsten electrodes; Rhenium

Introduction

Copper was most often used as the electrode material. The synthesis of elements was associated with the emergence of a stable “plasmoid” between the electrodes spaced at a distance of (1-1.5) D, where D is the inner diameter of the hollow electrodes (D≤50mm). The flow-through version was used (water circulation). The emergence of a “plasmoid” was initiated by a triggering electric discharge in the transverse direction with respect to the flow of water. In [2], vertical tungsten rods were used as electrodes. The flow-through version was not used. The potential difference between the electrodes did not exceed 340V. Potash (K₂CO₃) was added to distilled water to increase conductivity. No significant erosion of the electrodes was observed, and the appearance of new elements was recorded on the surface of the electrodes. The list of publications confirming the formation of elements in reactions of low-temperature synthesis is currently quite extensive and is constantly being updated. The main problem is the interpretation of the results. A possible explanation of the synthesis mechanism requires an extension of traditional concepts. This expansion is possible [3,4] using the inferences of hadronic mechanics [5]. At the same time, for the further development of the theory and improvement of the technology of synthesis of elements, it is advisable to build up the experimental data base.

In this work, pulsed electric discharges were carried out in distilled water, and, in contrast to [1,6], not tubular, but rod-shaped tungsten electrodes with hemispherical tips were used. The starting potential difference between the electrodes was 1kV. The gap between the electrodes is ≈0.7mm. The electrodes in the working cell were placed horizontally. The excess pressure in the cell was released through the valve. The water level in the cell, as a rule, corresponded to the full coverage of the electrodes. The flow-through version (water circulation) was not used. After several electrical discharges and evaporation of the liquid, about a milligram of white

***Corresponding author:** Nadezhda M Kashchenko, Institute of Physics and Technology, Ural Federal University named after the first President of Russia B N Yeltsin, Yekaterinburg, Russia

Submission:  December 23, 2021

Published:  January 12, 2022

Volume 8 - Issue 3

How to cite this article: Kashchenko MP, Pechorsky VI, Kashchenko NM, Nikolaeva NV, Pushin VG. Formation of Rhenium and Tantalum During Electrolysis of Distilled Water Using Tungsten Electrodes and the Expected Isotope Ratio. Aspects Min Miner Sci. 8(3). AMMS. 000688. 2022.
DOI: [10.31031/AMMS.2022.08.000688](https://doi.org/10.31031/AMMS.2022.08.000688)

Copyright@ Kashchenko NM, This article is distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use and redistribution provided that the original author and source are credited.

powder was obtained, sufficient for microanalysis of the chemical composition. In [7], the concept of a quasineutron is introduced as a bound state of a proton and an electron that exists in a wide range of spatial scales and corresponding energies. The publication [6] emphasizes that the presence of quasineutrons should manifest itself in the simplest synthesis reaction of elements with a charge number $z + 1$ at a charge number z of the electrode material. In particular, this conclusion was confirmed by the synthesis of zinc using copper electrodes in [6]. The main goal of this work is to detect rhenium and tantalum, the formation of which is expected as a result of the interaction of quasineutrons with tungsten ions extracted during electrode erosion [8].

About the Chemical Composition of the Particles of the Precipitated Powder

The initial chemical composition of the electrodes was determined at several randomly selected locations on the surface of the tungsten electrodes. One of the typical results correspond the measurement uncertainty is 0.01%. We emphasize that neither rhenium nor tantalum was fixed in the composition of the

electrode material. After several discharges, the polished surface of the electrodes clearly contained traces of material extraction. Figure 1 shows a fragment of the electrode surface: the light areas correspond to the areas of material extraction, and the dark areas correspond to the original intact surface. After discharges, an inhomogeneous composition is observed on the electrode surface due to the formation of chemical elements (for example, (in wt%) 97.67 W, 0.84 Fe, 0.65 Ag, 0.84 O or (in at.%) 87.84 W, 2.49 Fe, 1.01 Ag, 8.66 O). Without listing other options, we note that neither rhenium nor tantalum was found on the surface of the electrodes. Note that in [2], the appearance of Re, Os, Tm, Au was recorded on the surface of the electrodes. Most likely, their absence on the surface of the electrodes in our experiment is due to the short duration of electrolysis (only a few discharges were carried out) and the rather intense erosion of the electrodes. The main attention was paid to the analysis of the powder obtained after the evaporation of the solution formed in the course of electric discharges in water. Figure 2 shows the appearance of a part of the powder attached to an adhesive tape.

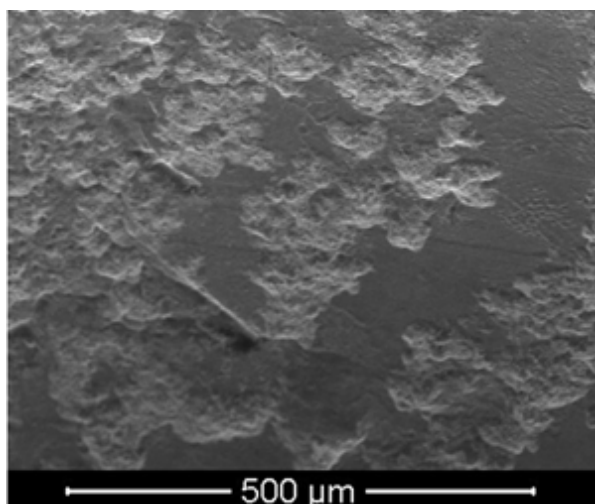


Figure 1: Fragment of the electrode surface after two discharges (magnification 200x).

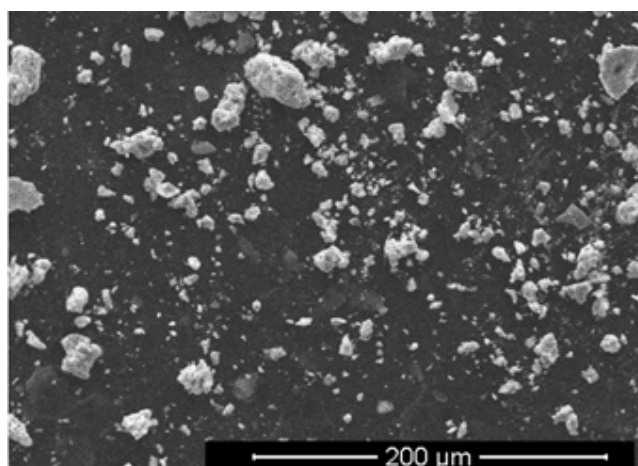


Figure 2: The view of a fragment of powder, fixed on scotch tape, with an increase of 500x.

The distribution map of elements shows that rhenium is present in the elemental composition of a number of particles. Table 1 shows the chemical composition of one of the spherical particles with a diameter of $\approx 1\mu\text{m}$. Particles containing tantalum have also been found. Table 2 shows the chemical composition of one of these particles. A characteristic feature of the particle composition is not only the formation of tantalum, but also a low tungsten content with a high niobium content. Particles containing neither rhenium nor tantalum are also observed. The composition of one of these particles is shown in Table 3. Note that a number of other elements are also observed. It is essential that the formation of elements occurred if a gas phase appeared in the cell during the electric discharge. Since the main goal of the work is to confirm the formation of elements adjacent to tungsten in the periodic table, we will not discuss here the reactions leading to the formation of

other observed elements. These reactions, especially the formation of niobium, deserve separate consideration.

Table 1: The chemical composition of one of the particles containing rhenium.

Element	O	K	Ca	Fe	W	Re
Weight %	11.62	1.3	0.86	2.29	78.33	3.04
At. %	56.37	1.85	1.67	3.18	33.08	1.27

Table 2: The chemical composition of one of the particles containing tantalum.

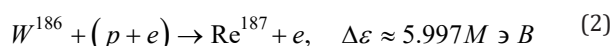
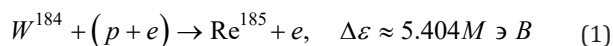
Element	O	Al	Si	Cr	Fe	Nb	Ta	W
Weight %	7.07	1.7	3.12	0.8	1.5	72.18	9.35	4.28
At. %	29.19	4.15	7.33	1.2	1.76	51.44	3.41	1.53

Table 3: The chemical composition of a particle without Re and Ta.

Element	C	O	S	Ag	K	Ca	Fe	Cu	W
Weight %	7.97	9.3	0.92	1.02	0.76	1.32	2.35	1.18	75.19
At. %	36.77	32.2	1.58	0.53	1.07	1.83	2.33	1.03	22.66

Discussion of Results

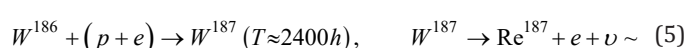
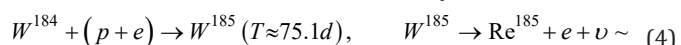
First of all, let us indicate the main reactions of rhenium synthesis during the fusion of tungsten nuclei with a proton, escorted by an electron. Recall that tungsten contains four stable isotopes W^{182} (26.50%), W^{183} (14.31%), W^{184} (30.64%), W^{186} (28.43%). Another isotope W^{180} (0.12%) has a half-life much longer than the age of the Universe. Hence, it is clear that the synthesis of rhenium, consisting of a mixture of two isotopes: stable Re^{185} (37.4%) and long-lived Re^{187} (62.6%) with a half-life $T \approx 4.1 \cdot 10^{10}$ years, is quite expected:



Estimates of the binding energy ΔE in exothermic reactions (1) and (2) were obtained using tabular data on atomic masses without taking into account the quasineutron binding energy. Three additional unstable isotopes Re^{181} ($T \approx 19.9\text{h}$), Re^{183} ($T \approx 70\text{d}$), Re^{184} ($T \approx 35.4\text{d}$) immediately after formation can also contribute to the rhenium content, however, β^+ - decay or electron capture leads to the stable isotopes W^{183} , W^{182} and the stable isotope Ta^{181} (natural tantalum consists of a mixture of a stable isotope and a stable isomer: Ta^{180m} (0.012%), Ta^{181} (99.988%)). Note that the capture of a quasineutron by the W^{180} isotope with the formation of an unstable isotope W^{181} also (after electron capture) leads to Ta^{181} . Reactions



can lead to a change in the fraction of stable isotopes, but not to the nuclei of new elements. On the contrary, the reactions

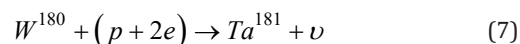


lead to the formation of rhenium.

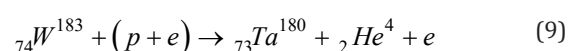
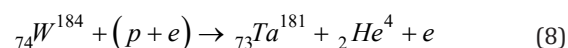
Assuming reactions (1) and (2) the most probable for the formation of rhenium isotopes, we can assume that the expected ratio of the fractions of rhenium isotopes [$f(Re^{187})/f(Re^{185})$] $\text{exp} \approx$ is given (in the "zero approximation") by the ratio of the corresponding fractions of isotopes tungsten in nature

$$\left[\frac{f(Re^{187})}{f(Re^{185})} \right]_{\text{exp}} \approx \left[\frac{f({}_{74}W^{186})}{f({}_{74}W^{184})} \right]_{\text{nat}} \approx 0.93 \quad (6)$$

Result (6) sharply differs from the characteristic ratio of rhenium isotopes in nature. The absorption of an electron by tungsten nuclei leads to only one stable isotope of tantalum, Ta^{180} . Isotopes Ta^{182} ($T \approx 114.74\text{d}$), Ta^{183} ($T \approx 5.1\text{d}$), Ta^{184} ($T \approx 8.7\text{h}$), Ta^{186} ($T \approx 10.5\text{m}$) undergo β^- - decay, reducing initial isotopes of tungsten W^{182} , 183 , 184 , 186 . Note that tantalum isotopes can also arise during the capture of a pseudoproton ($p+2e$) by tungsten nuclei, which, according to [9], is a bound state of a proton with two electrons. For example



where ν is the symbol of the electron neutrino. The inclusion of one neutrino in the right-hand side suggests that the quasineutron state ($p+e$), like the neutron, is assigned a zero-lepton charge, while the pseudoproton ($p+2e$), like an electron, has a unit lepton charge. As a result, in reaction (7), the lepton charge conservation law is formally fulfilled. Along with the synthesis of rhenium during the capture of a proton by the isotopes $W^{184,186}$, the capture of a proton by the isotopes $W^{184,183}$ can be accompanied by a reaction with the formation of tantalum and helium



If (8) and (9) are the main reactions of the formation of Ta, then the expected ratio of the fractions of isotopes $[f(\text{Ta}^{181})/f(\text{Ta}^{180})]_{\text{exp}}$ will actually be set by the ratio of the corresponding fractions of tungsten isotopes in nature

$$\left[\frac{f({}_{73}\text{Ta}^{181})}{f({}_{73}\text{Ta}^{180})} \right]_{\text{exp}} \approx \left[\frac{f({}_{74}\text{W}^{184})}{f({}_{74}\text{W}^{183})} \right]_{\text{nat}} \approx 2.14 \quad (10)$$

This would be in stark contrast to the proportion of tantalum isotopes in nature

$$\left[\frac{f(\text{Ta}^{181})}{f(\text{Ta}^{180})} \right]_{\text{nat}} \approx 8.33 \times 10^3 \quad (11)$$

We neglected the contribution of the reaction ${}_{74}\text{W}^{180} + e \rightarrow \text{Ta}^{180}$, as well as (7), since the content of the isotope W180 in nature is low. In the case of a short electrolysis time, and most importantly, for short time intervals (compared to T in (3)-(5)) between electrolysis and mass spectrometry of the solid fraction of electrolysis products, the neglect of possible reactions (3)-(5) is also justified.

However, it is clear in advance that the absorption processes of quasineutrons cannot fundamentally affect the difference in orders when comparing (10) and (11). We emphasize that the prediction of the expected quantitative ratio of the fractions of isotopes of the formed elements within the framework of the concept of quasineutron states was made earlier [4] for the ratio of the fractions of zinc isotopes, when zinc is synthesized as a result of electric discharges in water using copper electrodes. In the case of the formation of rhenium and tantalum, the differences between the expected (based on experiments on the formation of isotopes) and those observed in nature are much more dramatic. This can be seen when comparing data (6) and (7) and especially (10) and (11).

Conclusion

The formation of rhenium and tantalum during the passage of electric current pulses in water in the case of tungsten electrodes supports the concept of quasineutron states. Moreover, in the simplest case of a reaction with the absorption of a proton, it is not difficult to propose an estimate for the ratios of the fractions of the formed isotopes of rhenium and tantalum. A significant difference between these ratios from those observed in nature would not only be an additional confirmation of the artificial origin of rhenium and tantalum but would also directly indicate the mechanism of their occurrence. It seems expedient to check the conclusions about the ratio of isotopic fractions of the formed elements using mass spectrometry.

Acknowledgment

The authors express their gratitude to the Ministry of Science and Higher Education of Russia for their support in the execution of state assignment No. 075-00243-20-01 dated 26.08.2020 within the framework of the theme FEUG-2020-0013 "Environmental aspects of rational nature management".

References

- Lokkas P, Papadimitriou E, Alamanis N, Papageorgiou G, Christodoulou D, et al. (2021) Significant foundation techniques for education: A critical analysis. *WSEAS Transactions on Advances in Engineering Education* 18(2): 7-26.
- Lokkas P, Chouliaras I, Chrisanidis T, Christodoulou D, Papadimitriou E, et al. (2021) Historical background and evolution of soil mechanics. *WSEAS Transactions on Advances in Engineering Education* 18: 96-113.
- Alamanis N (2017) Failure of slopes and embankments under static and seismic loading. *American Scientific Research Journal for Engineering, Technology and Sciences (ASRJETS)* 35(1): 95-126.
- Papageorgiou GP, Alamanis N, Xafoulis N (2020) Acceptable movements of road embankments. *Electronic Journal of Structural Engineering* 20(1): 30-32.
- Nikolaos A, Christos Z, Grigorios P, Nikolaos X, Ioannis C (2020) Risk of retaining systems for deep excavations in urban road infrastructure with respect to work staff perception. *International Journal of Scientific & Technology Research* 9(2): 4168-4175.
- Zachos D, Bakalis G, Bakalis K, Alamanis N, Papageorgiou G, et al. (2021) A methodology for selecting the required cross-section of a self-supporting retaining bulkhead, on a vertical excavation front, of an energy conduit passage trench. *Energy Systems* 12: 989-1002.
- Alamanis N, Dakoulas P (2019) Simulation of random soil properties by the local average subdivision method and engineering applications. *Energy Systems* 12: 841-861.
- Alamanis N, Dakoulas P (2021) Effect of spatial variability of soil properties on permanent seismic displacements of slopes with uniform load. 14th Baltic Sea Geotechnical Conference, Helsinki, Finland.
- Zebovitz S, Krizek R, Atmatzidis D (1989) Injection of fine sands with very fine cement grout. *Journal of Geotechnical Engineering* 115: 1717-1733.
- Christodoulou DN, Droudakis AI, Pantazopoulos IA, Markou IN, Atmatzidis DK (2009) Groutability and effectiveness of microfine cement grouts. In: Hamza et al. (Ed.), 17th International Conference on Soil Mechanics and Geotechnical Engineering: The Academia and Practice of Geotechnical Engineering, Alexandria, IOS Press, Egypt, 3: 2232-2235.
- Pantazopoulos IA, Markou IN, Christodoulou DN, Droudakis AI, Atmatzidis DK, et al. (2012) Development of microfine cement grouts by pulverizing ordinary cements. *Cement and Concrete Composites* 34(5): 593-603.
- Markou IN, Christodoulou DN, Petala ES, Atmatzidis DK (2018) Injectability of microfine cement grouts into limestone sands with different gradations: Experimental investigation and prediction. *Geotechnical and Geological Engineering Journal* 36(2): 959-981.
- Markou IN, Christodoulou DN, Papadopoulos BK (2015) Penetrability of microfine cement grouts: Experimental investigation and fuzzy regression modeling. *Canadian Geotechnical Journal* 52(7): 868-882.
- Christodoulou D, Lokkas P, Markou I, Droudakis A, Chouliaras I, et al. (2021) Principles and developments in soil grouting: A historical review. *WSEAS Transactions on Advances in Engineering Education* 18(18): 175-191.