

STUDY OF THE REGULARITIES OF STRUCTURAL-PHASE CHANGES IN KIDNEY STONES CONTAINING U-235, 238 ISOTOPES AMONG PATIENTS OF THE KHARKIV REGION IN THE LONG-TERM ASPECT

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This report describes structural and phase changes in kidney stones containing uranium isotopes (~ 1 ppm) among patients of the Kharkiv region in 2025. The spectrum of chemical compounds within the kidney stones was identified. Analysis of the obtained IR absorption spectra and crystal optics data revealed that the mineral composition of the kidney stones is characterized mainly by the presence of two mineral phases: whewellite and weddellite. The presence of uranium, a promoter of oxidation processes and an α -emitter, leads to a more accelerated and simplified forming composition of kidney stones. The detailed mechanisms of the effects of nanoscale uranium on the human body require further study.

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INTRODUCTION

Naturally occurring radioactive uranium, widespread in the biosphere, typically enters water bodies from rocks. Living organisms respond to the influx of water from such bodies of water by altering the concentration of physiological fluids, disrupting the structure of epithelial cells, their wettability, and other factors.

It is known that the presence of uranium in the body leads to increased formation of active forms of oxygen, which is a promoter of oxidative processes [1–3]. The induction of oxidative processes in the body may be related to both the chemical properties of this heavy metal and its radioactivity as an α -emitter. Even in low concentrations, uranium can alter the body's antioxidant status [4].

Consequently, the presence of even nanoconcentrations of uranium in the body can lead to changes in the function and properties of cell membranes due to the formation of various complexes of uranium with membrane phospholipids [5].

There is also a disruption in the mechanism for synthesizing inhibitors that should prevent the formation and growth of any stones, including kidney stones.

The morphological features of the main kidney stones are known [6]. The most stable phase-morphological combinations were chosen as the main criterion for classifying kidney stones that had been studied previously. This paper will not present descriptions of the appearance, color, and character of kidney stones, as these descriptions have been given in a previous paper [7].

There are virtually no scientific studies examining the cellular and molecular mechanisms by which uranium toxicity influences the formation of kidney stone phase composition. This indicates the need for more detailed research in this area. Previous work has shown that kidney stone composition formation is a multifactorial process and depends not only on uranium intake with water [8].

The aim of this work is to further study the structural and phase changes in kidney stones

containing uranium (~ 1 ppm) during the period of military operations (2025).

1. MATERIALS AND METHODS

IR-spectroscopy is a suitable method, which give information about the composition of kidney stones and identifying not only the molecular species present in stones but also the crystalline forms.

The kidney stones from 34 patients in the Kharkiv region were used. The kidney stones washed many times with distilled water, then dried $T=37^{\circ}\text{C}$ and crushed in agate mortar. The samples prepared in the form of tablets with of KBr (sizes 25x5 mm), (the pressure was 9200 kg/cm²), which served as matrix and the test substance (in amount of 1 %, 100 mg sample). The evaluation carried out on the spectrum of polystyrene with a known frequency of absorption maxima. Correction averaged 10...5 cm⁻¹.

The IR-spectrometer IRS-29 (LOMO) used to record absorption spectra in the infrared range. The spectra were recorded in the spectral range 4000...400 cm⁻¹.

Crystal-optical studies were performed using POLAM-L211 microscope with immersion liquids (set IJ, OVIJ).

2. RESEARCH RESULTS

2.1. GENERAL MICROSCOPIC CHARACTERISTICS OF KIDNEY STONES CONTAINING URANIUM ISOTOPES, ACCORDING TO CRYSTAL-OPTICAL ANALYSIS

The examined kidney stones (in the form of an immersion preparation) consisted of transparent, irregularly shaped grains of crystalline calcium oxalate dihydrate (CaC₂O₄·2H₂O, mineral – weddellite, ~ 40...50% by volume) and crystalline calcium oxalate monohydrate (CaC₂O₄·H₂O, mineral – whewellite, ~50...60% by volume). Both minerals exhibited an atypical appearance and grain shape, which is caused by a large number of structural defects and impurities.

The size of transparent weddellite crystals was ~20...40 μm (~ 40...50% by volume). Large brown

whewellite crystals reached ~40...80 μm in size with a characteristic banded texture (~50...60% by volume).

The Fig. 1,a,b shows microphotograph of a kidney stone, consisting of whewellite (calcium oxalate monohydrate).

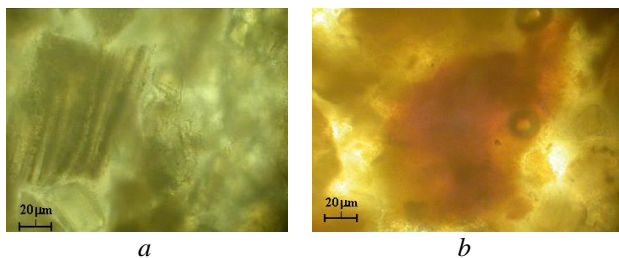


Fig. 1. Microphotograph of a kidney stone, consisting of whewellite (calcium oxalate monohydrate). Under transmitted light without an analyser. Crystalline whewellite (a), and whewellite with a disordered semi-amorphous structure (b)

The Fig. 2 shows microphotograph of a kidney stone, consisting of wheddellite (calcium oxalate dihydrate).

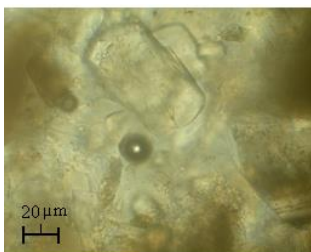


Fig. 2. Microphotograph of a kidney stone, consisting of wheddellite (calcium oxalate dihydrate). Under transmitted light without an analyser

The Fig. 3 shows microphotograph of a kidney stone, consisting of whewellite + wheddellite (calcium oxalate monohydrate and calcium oxalate dihydrate).

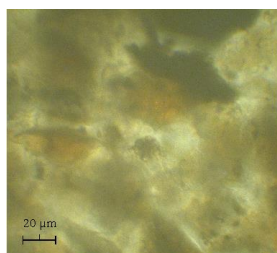


Fig. 3. Microphotograph of a kidney stone, consisting of whewellite + wheddellite (calcium oxalate monohydrate and calcium oxalate dihydrate). Under transmitted light without an analyser

2.2. SPECTRUM OF CHEMICAL COMPOUNDS IN KIDNEY STONES CONTAINING URANIUM ISOTOPES, AS ANALYZED BY IR ABSORPTION SPECTRA

The phase composition of kidney stones, based on IR spectroscopy data in the absorption range from 440 to 3360 cm^{-1} , confirms the identification of a combination of whewellite and weddellite for all samples studied.

The presence of uranium in the body causes an imbalance between pro- and antioxidant products,

leading to accelerated crystallization and stone formation [9]. Rapidly formed kidney stones exhibit a simplified spectrum of chemical compounds. Only two types of monophasic stones were identified in the samples studied (whewellite, calcium oxalate monohydrate, and weddellite, calcium oxalate dihydrate). Calcium is a component of almost all kidney stones in the majority of patients with urolithiasis [10].

Uranium and calcium have similar ionic radii, allowing uranium, as the more active element, to displace calcium and bind to other organic groups in kidney stones. Ca/U substitution reactions are known and well studied both in nature and experimentally [11].

CONCLUSIONS

The general characteristics of kidney stones containing uranium isotopes (~ 1 ppm), according to crystal optics and IR spectroscopy data in the absorption region from 440...3360 cm^{-2} , confirm the identification of the whewellite + weddellite combination for all the studied samples (2025 year).

Uranium simplifies the mineral phase composition and accelerates stone formation. The detailed mechanisms of the effects of nano-quantities of uranium on the human body require further study.

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ВИВЧЕННЯ ЗАКОНОМІРНОСТЕЙ СТРУКТУРНО-ФАЗОВИХ ЗМІН У НИРКОВИХ КАМЕНЯХ, ЯКІ МІСТЯТЬ ІЗОТОПИ U-235, 238, СЕРЕД ПАЦІЄНТІВ ХАРКІВСЬКОГО РЕГІОНУ В ДОВГОСТРОКОВІЙ ПЕРСПЕКТИВІ

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Описано структурні та фазові зміни в ниркових каменях, що містять ізотоп урану (~ 1 ppm), у пацієнтів Харківської області у 2025 році. Було визначено спектр хімічних сполук, що містяться в ниркових каменях. Аналіз отриманих ІЧ-спектрів поглинання та даних кристалооптики показав, що мінеральний склад ниркових каменів характеризується переважно наявністю двох мінеральних фаз: вевеліту та ведделіту. Присутність урану, промотора процесів окислення та α -випромінювача, призводить до більш прискореного та спрощеного утворення каменів у нирках. Детальні механізми впливу нанорозмірного урану на організм людини потребують подальшого вивчення.