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Education

ELEMENTARY, MY DEAR WATSON! THE MAKING OF A COLLECTION OF THE NATURAL ELEMENTS

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A unique collection of samples of the chemical elements has been created and displayed at our Institute of Chemistry. Although whole collections are now commercially available, we decided to use, as much as possible, samples from local resources. The general idea was for each item to have a story, making it more interesting for the students and visitors. We were able to acquire elemental samples mined in Macedonia. Other samples were from our student and research labs, as well as donations from colleagues, and the rest were obtained from commercial sources. A web page was created with all the information on each sample, some of them containing videos. Next to the noble gases, mini Tesla coils were mounted to light up the gases.

Keywords: periodic table; elemental samples; sample display frame; Tesla coils; chemical elements from Macedonia

ЕЛЕМЕНТАРНО, ДРАГ МОЈ ВОТСОН! СОЗДАВАЊЕ ЗБИРКА ПРИРОДНИ ЕЛЕМЕНТИ

Во Институтот за хемија е создадена и изложена единствена збирка на примероци на хемиските елементи. Иако денеска комерцијално се достапни цели збирки, одлучивме да користиме, колку што е тоа можно, примероци од локални извори. Општата идеја беше секој примерок да има своја приказна, со цел да побуди поголем интерес кај студентите и посетителите. Успеавме да добиеме примероци на елементи што се ископувале и добивале во Македонија. Други примероци потекнуваат од нашите студентски и научни лаборатории и како донации од колеги, додека сите други беа комерцијално набавени. Направена е веб-страница со сите податоци за секој примерок, при што за некои има и видео записи. До благородните гасови се поставени мини Теслини трансформатори што овозможува светење на гасовите.

Клучни зборови: периоден систем; примероци на елементи; витрина за елементи; Теслини трансформатори; хемиски елементи од Македонија

Usually, every chemistry lab or chemistry lecture room has one or several of the forms of the periodic table of the elements. However, not all chemistry or science departments have a collection of the chemical elements. Interestingly, the collection of chemical elements has become a popular hobby even among non-chemists.[1,2,3] Besides the individual elements,[4] ready-made sets are commercially available – some as standardized collections but others as very elaborate custom made collections with exceptional quality and prices.[5]

The idea of displaying a collection of the elements has been brewing for years in both of us individually, and only recently did we discover our common interest. One of us (MN) had privately bought some of the elements as well as a portable

display for classroom use. Our initial dilemma was finding a suitable place at the Institute of Chemistry for the collection. The first idea was to adapt a glass wall, 2 m × 3 m, separating our library with the main hall at the Institute. It is a perfect place because it has a central position where all lecture rooms are located and where students mainly congregate. An unsurmountable obstacle was that it would have required professional construction that was beyond our means at this time.

A standalone bulletin board at our Institute caught our eyes, especially given that in this digital age, it is rarely being used anymore. It is located in the hall in front of the inorganic and organic labs and leads to our grand amphitheater. The dimensions (130 cm × 80 cm × 4.5 cm) were small compared to our initial idea but seemed to be an acceptable alternative for displaying the element collection. It could accommodate a skeleton frame[6] in the shape of the well-established form of the periodic table with cells measuring 6 cm × 6 cm × 4 cm. We found a local company specializing mostly in neon signs that made it from transparent 3 mm thick acrylic glass. On the back of the cells, the periodic table was printed with only the color-coded symbol of the elements according to their physical state at room temperature and their atomic numbers. We were more than satisfied with the quality of the workmanship because it was not intrusive and the elemental samples would not be obscured by the frame. Furthermore, they also installed LED lights around the frame to enhance their visibility. We added an infrared sensor that turns on the lights as one approaches the display.

Initially, we planned to place each element in a 10 ml vial, but after displaying the first samples, we decided to simply place the samples of stable elements in the cells. The idea actually came from a wall chart of the elements with such pictures in our main amphitheater, which was published by the Royal Society of Chemistry and Time-Life in 1987. We decided to move this wall chart next to our display for comparison but also to complement the lack of the radioactive elements. We feel that they do make a great combination (Fig. 1).

Fig. 1. The elemental samples display with the picture of the periodic table published by the Royal Society of Chemistry and Time-Life

However, unlike the pictures of the elements, we had to protect some of the elements from oxidation in glass ampoules under an inert atmosphere. Others, like iodine, also had to be enclosed in an ampoule in order not to lose it to sublimation. On the other hand, bromine and mercury, due to their high toxicity, had to also be embedded in an acrylic block to protect the ampoules from breaking. Initially, we even wanted to try to obtain a sample of depleted uranium used in the NATO bombing of Yugoslavia.[7] We are still debating the

safety issues and whether we will be able to obtain a sample for our collection.

To make the collection more interesting, we wanted to give it a local flair so we decided to look for elemental samples available in Macedonia. We thought this is essential also from a pedagogical point of view to teach our and other students about the available natural resources and manufacturing facilities in our country. For example, Macedonia has several iron ore mines, and at one time, a steel mill in Skopje produced steel from those mines. Nowadays, the steel produced is from scrap metal, but after contacting some of our former students, we were able to obtain an iron sample from the time it was mainly produced from the Tajmište ore mine in Macedonia.

In order to give such information for the elemental samples, it was only natural to create a web page with full information. A QR code on the collection display leads to the web page (Fig. 2). An active picture of each sample is given, which makes it easy to locate the element information. The page is bilingual, in Macedonian and in English.

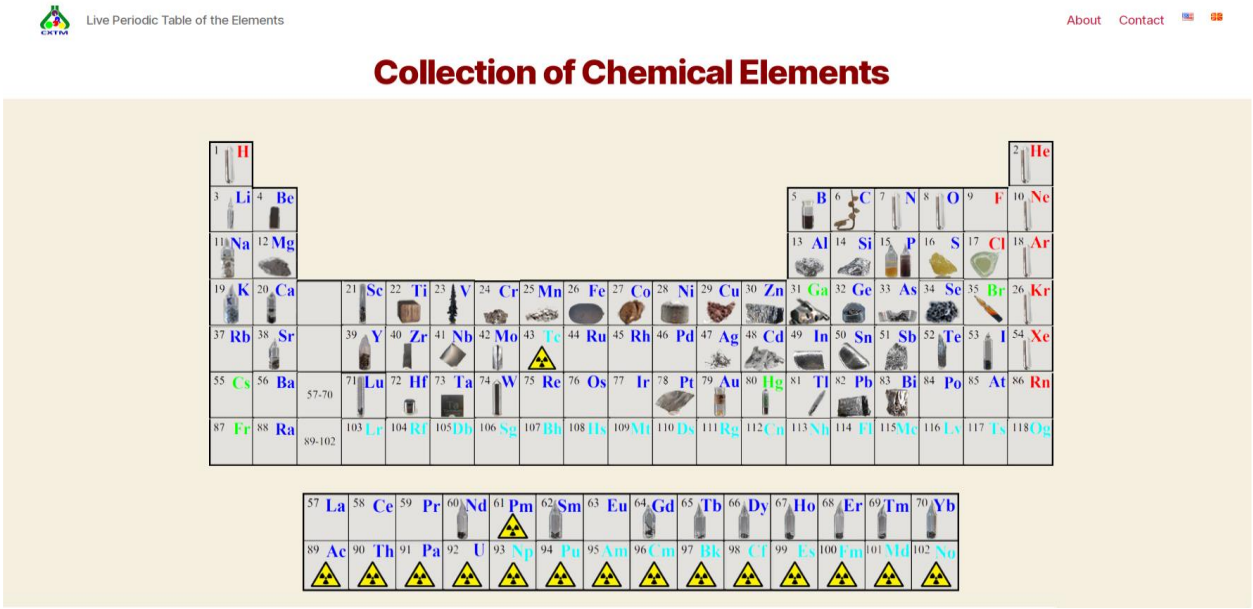

Fig. 2. Screenshot of the web page with information on each elemental sample

For each sample, besides the element name, the picture of the sample, origin, and some basic physical data are given (Fig. 3). Also, a link to the WebElements™ page is available where extended information for each element is available. It is probably the best online source for information on the chemical elements, which is regularly updated.[8] We are also considering adding the analysis of the purity of some of the samples, making the whole collection even more interesting for the students who have had courses in instrumental methods of analysis.

Yugoslavia was a large producer of aluminum from bauxite; as a matter of fact, in 1984, it had 3.6 % of the world's production.[9] There was an aluminum processing plant in Skopje for various profiles from aluminum ingots. Unfortunately, we have not been able to find a confirmed genuine sample of aluminum from that time[1]. Because aluminum is indefinitely recyclable and in order to make the students aware of this fact, we decided to make our own sample from a beer can. Naturally, the beer can was from a beer produced in our home town. A sequence of pictures showing the whole procedure (without the step of drinking the beer) was added to the web site.

Another element that was produced in-house was chlorine. The method is exactly the one students use in their first year general chemistry lab course, from permanganate and hydrochloric acid.

We added two samples of carbon, the graphite allotrope found in our country and also a sample of artificial diamond tips from a saw used in one of our marble quarries.

Besides iron and carbon, the following elemental samples were obtained from Macedonia: copper, indium, lead, silicon, silver, sulfur, and zinc.

[1] After the manuscript was accepted for publication, we have obtained an authentic sample and added it to the collection!

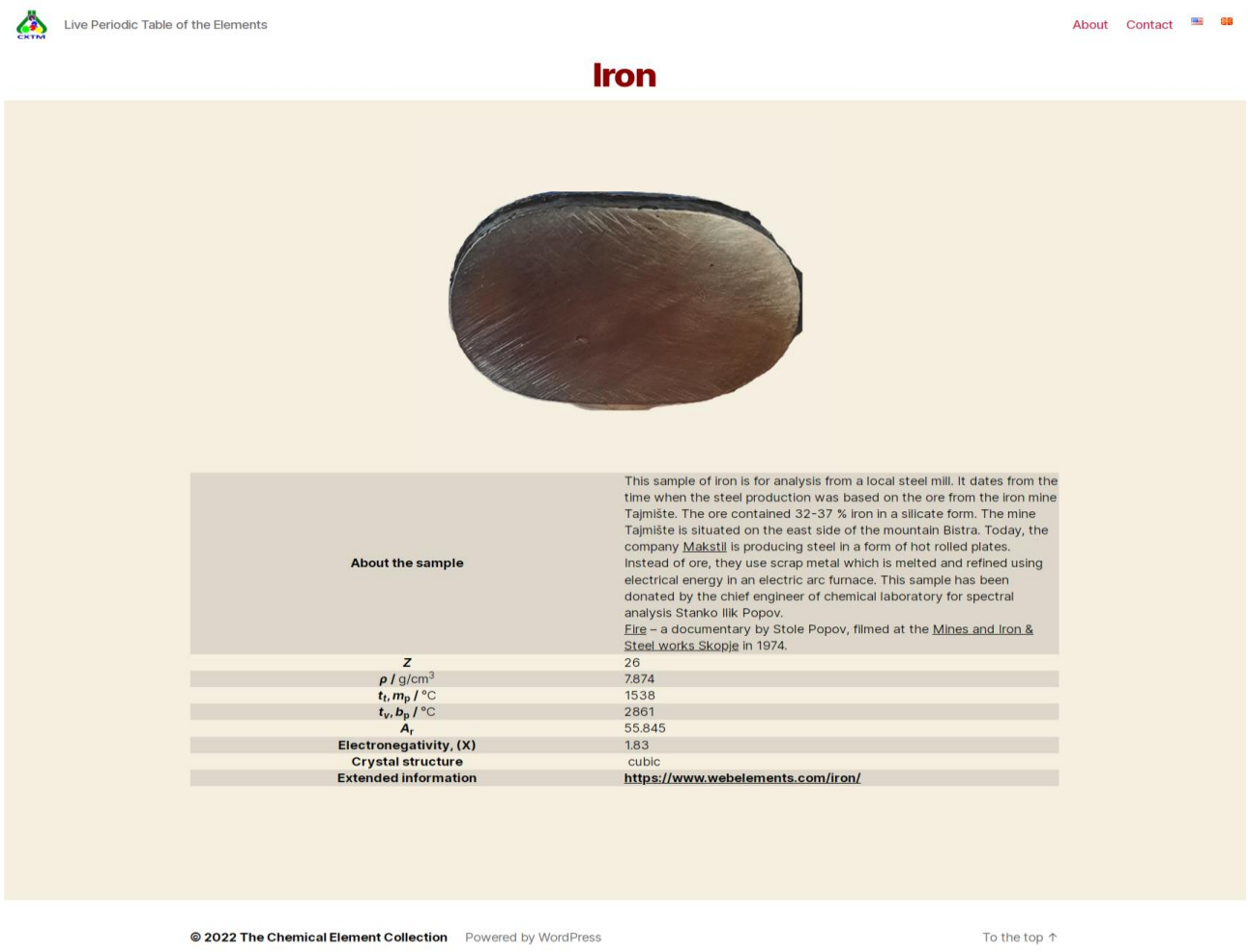

Fig. 3. The web page for the iron sample

A large number of chemical samples were obtained from our student or research labs at the Institute of Chemistry: bromine, cadmium, iodine, mercury, phosphorus, platinum, potassium, sodium, and tin. Even the ampoules of helium and argon were filled by the gases used in our gas chromatography and atomic absorption research labs.

Germanium and molybdenum were donated by our colleague at the Institute of Physics.

Other samples were provided by our former students and colleagues from abroad: antimony, lutetium, nickel, niobium, rhenium, scandium, tellurium, and tungsten.

The rest of the samples were bought from commercial sources: arsenic, beryllium, bismuth, boron, calcium, chromium, cobalt, dysprosium, erbium, gadolinium, gallium, gold, hafnium, holmium, hydrogen, krypton, lithium, manganese, neodymium, neon, nitrogen, oxygen, samarium, selenium, strontium, tantalum, terbium, thallium, thulium, titanium, vanadium, xenon, ytterbium, yttrium, and zirconium. We do hope that we will be able to replace some of these samples with ones that have a local story.

Another interesting and attractive feature of the display is that there are mini Tesla coils beside the noble gases. By pressing a button, the main light is turned off and the coils are activated, which in turn light up the noble gases (Fig. 4). The coils are active for only 30 s and then cannot be activated for ~5 min in order to protect the transistors of the Tesla coils from overheating. On the web page, a video of the active Tesla coils is provided.

CONCLUSION

In less than six months, a display, frame, and substantial collection of samples of the chemical elements were created. Many have some local provenance, making them more interesting to the students and visitors. The stable ones are displayed as they are, but others had to be protected in glass ampoules. The noble gases glow initiated via miniature Tesla coils. A QR code on the display leads

to a web page with information of each sample. We have been considering adding an analysis of the purity of some of the samples and including this information, thus widening the instructive significance of the collection. We encourage others to make their own unique collection of samples of the chemical elements.

It may sound simple, but many problems with limited funds had to be solved in order to make such an attractive and educational display. We are proud that we have had more than 80 years of experience between the two of us in many areas of chemistry, including with various experimental methods. So after all, we can proudly say: Elementary, my dear Watson!

Fig. 4. A picture of the noble gases with the Tesla coils

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