Discussion on the temperature influence of Pb/Cu/Ni/Mo precipitation in copper faucets

Huang Tingting1,2,3*, Chen Renjie1,2, Huang Wenjia1, Wang Jiannan1,2, Guo Liping1,2, Xie Meimei1,2 and Cai Jinzhang1,2

1Nanan Testing Institute of Quality and Metrology, Quanzhou, Fujian, China
2National Quality Supervision and Inspection Center of Plumbing & Sanitary Ware (Fujian), Quanzhou, Fujian, China
3Nanan Market Supervision and Comprehensive Law Enforcement Brigade, Quanzhou, Fujian, China

* Corresponding author: tthuang411@foxmail.com

Abstract. Precipitation of harmful substances in the faucets has always been the focus of attention, this experiment selected the four metal elements of Pb/Cu/Ni/Mo as the research object, and studied the precipitation in the faucets which were extracted at the ambient temperature of 20℃, 40℃ and 60℃. The results showed that the Pb and Mo precipitation in the faucets increased with the temperature rise, while the Cu and Ni in most samples were the least precipitated at 60℃. Detection found that the metals precipitation among different batches and different samples in the same batch varied widely, mainly affected by the processing technology and the material of faucets.

1. Introduction

Water is the source of life, is an indispensable part of people's lives, and people's healthy life can not be separated from safe drinking water. With the enhancement of people's health consciousness, the faucets, as the terminal of the water supply system, is one of the essentials of household life, the problem of heavy metal precipitation has been widely concerned by the public. Because of its material and processing technology problems, the faucets often have the problem of lead, nickel, copper, chromium and other heavy metals precipitation. Lead accumulation in the human body can cause damage to the nervous system, kidneys, hematopoietic system and blood vessels, and will have greater adverse effects on children and adolescents in growth and development, especially in fetuses, which can lead to congenital low intelligence, nervous system disorders, cancerous changes and genetic mutations. Nickel is an essential element of the human body, but the demand is very small. Once exceeded the standard will harm human health, can cause severe dermatitis and skin allergies, damage the body's liver, heart and lung function, leading to pulmonary edema, acute pneumonia, and even respiratory cancer. Copper is also an essential trace element of the human body, but when copper accumulates in the human body to a certain extent, it will directly affect the growth and development of the human body, physiological and biochemical function, the human body ingests too much copper can cause acute copper poisoning, liver bean-like nuclear degeneration, bile siltation in children's liver and other conditions. In addition, copper has obvious anti-fertility effect, seriously affecting the human reproductive system, leading to infertility. Although molybdenum is a trace element that our human body needs, but when excessive will also be extremely harmful to human life and health, it can make
the body's energy metabolism process obstacles, myocardial hypoxia and necrosis, prone to kidney stones and urethra stones, increase the rate of iron deficiency anemia disease. At the same time, molybdenum is the leading cause of esophageal cancer. It can also cause gout like syndrome, joint pain and deformities, kidney damage, stunted growth, weight loss, hair loss, atherosclerosis, connective tissue degeneration and skin diseases.

According to the study, the heavy metal precipitation in the faucets had a certain correlation with the content of the elements in the material, and at the daily room temperature, the small range of pH and electrical conductivity had little influence on the heavy metal precipitation, the influence factor was the extraction time [1]. However, With the development of science and technology and the improvement of living standards, now the general household faucets have a temperature control function. The precipitation of harmful contaminants from faucets is a complex electrochemical corrosion process, which is also affected by the temperature [2]. This research selected Pb/Cu/Ni/Mo as the main research objects, and studied the precipitation in different temperature conditions, with the aim of providing scientific basis for the safety of drinking water and industrial production.

2. Experiment

2.1. Equipment and reagents

2.1.1. Equipment
Standard solution: Nexion™ 350X ICPMS (USA Perkin Elmer company), Mini-q Reference Ultra Pure Water system (USA Millipore company), PH meter (Mettler-toledo), Conductivity meter (Mettler-toledo).

2.1.2. Reagents
Standard solution: 1000μg/mL of Pb (GBW08619), Ni (GBW08618), Cu (GBW08615) were purchased from the China Institute of Metrology, 1000 μg/mL Mo (GBW (E) 080133) was purchased from the nuclear industry Beijing Institute of Chemical Metallurgy.

Other reagents: waterless NaHCO3 (AR), 5% sodium hypochlorite solution (AR), nitric acid (GR) were all purchased from Shanghai Guo pharmaceutical group chemical reagents Co. Ltd.; Ultra Pure Water (electrical resistivity ≥ 18.2 MΩ·cm)

2.2. Test method

2.2.1. The extraction of faucets samples
According to the GB18145-2014 Appendix B method [3], the extraction solution that simulates tap water is formulated. This experimental samples which were inferior copper faucets were prepared, a total of 5 batches, respectively, 1#, 2#, 3#, 4#, 5#. Each batch had 9 parallel samples. The samples were rinsed with tap water for 15 min, then 3 times with ultra pure water, the residue and dirt from the sample were washed out, and then 3 times with extraction solution. Each batch of samples was taken in 3 parallel samples at an ambient temperature of 20℃, 40℃, 60℃ for extraction experiments. The samples were fully filled with extraction solution, and the sample handle switch was in a fully open state, and both ends of the sample were tightly plugged with a clean rubber plug covered with Teflon film. After the sample filled with the extraction solution had stabilized at its respective ambient temperature of no more than 72 h, the extraction solution in the sample was replaced in accordance with appendix B of GB18145-2014, and the held for 16 h extraction solution in the sample was collected for 5 days after stabilization. The 3# samples were repeated the above steps and collected the extraction solution for the next 5 days. The extracted solution was added with nitric acid to make the solution pH <2 and placed at room temperature for more than 24 h to ensure that the metal is completely dissolved prior to analysis for inspection.
2.2.2. Test
The concentration of Pb/Cu/Ni/Mo in the extraction solution were determined by inductively coupled plasma mass spectrometer (ICP-MS). Considering the factors such as abundance, interference and sensitivity, $^{208}\text{Pb}/^{63}\text{Cu}/^{60}\text{Ni}/^{98}\text{Mo}$ isotope were selected for testing. $^{45}\text{Sc}/^{115}\text{In}/^{187}\text{Re}$ were chosen as the internal standard element, and online labeling method was adopted.

Instrument working conditions: RF (1.6 KW), Carrier Gas (Argon): 0.90 L/min, Cooling gas (Argon): 15.0 L/min, Helium: 4.5 mL/min, Sweeps/reading (20), Readings/replicate (2), Number of Replicate (2), Detector Mode (Dual), KED mode.

3. Results and discussion

3.1. Influence of temperature on precipitation of Pb/Cu/Ni/Mo in different batches of faucets extracted for 5 days

The experiment selected 5 batches, 9 parallel samples per batch, and 3 parallel samples at three degree ambient temperature. The concentration of Pb/Cu/Ni/Mo precipitation of 5 days of extraction solution were detected by ICP-MS. Each batch of 3 parallel samples per day for the weighted average was defined as the derived value of the batch. As the temperature changes, The precipitation of heavy metals in the test samples were as follows.

As shown in Figure 1, the precipitation of Pb showed a clear trend: the concentration of precipitation increased with the rise of temperature, and the increase rate of 60 °C compared with 40 °C was higher than that of 20 °C compared with 40 °C, indicating that the Pb precipitation increased significantly at high temperature, and did not show an obvious decrease trend with the increase of extracting days.

As shown in Figure 2, the concentration of copper precipitated at 20°C and 40 °C were similar, and both of them were higher than that at 60 °C which indicated that the copper precipitation was more easily at lower temperature. Because the faucet made of copper alloy were selected as the research object in the test samples. The copper content was relatively high, so its precipitation was generally high, most of which were higher than 150 mg/L.

As shown in Figure 3, there was a relatively large difference in the concentration of Ni precipitation among samples. The precipitation concentration of 2# and 5# samples were relatively high, and the precipitation trend increased first and then decreased with the increase of extracting days. And it was generally more at 40 °C and 60 °C than at 20 °C. The precipitation of 1#, 3# and 4# samples were lower, and the precipitation of all the three samples at 20 °C was higher than that at other temperatures. This may be related to the Ni content in the faucets material (or the difference in nickel plating process). If the nickel plating process was not cleaned completely, the nickel precipitation will be higher when the temperature is higher, especially at the temperature of the nickel plating process (40-45 °C). It is easier to precipitate. However, after the nickel plating reagent remained on the surface of faucets was precipitated out.
Fig. 1.  Pb precipitation in 5 batches samples for 5 days at 20 ℃, 40 ℃, 60 ℃

Fig. 2.  Cu precipitation in 5 batches samples for 5 days at 20 ℃, 40 ℃, 60 ℃
The precipitation was mainly from the original material of faucets and it is easier to precipitate out at 20 °C. The 2# and 5# samples also showed this characteristic in d5 extraction solution.

As shown in Figure 4, the precipitation of Mo was generally relatively low, with the highest being less than 0.90 mg/L. And the precipitation concentration of all the five samples were highest on the first day, and then they all weakened. The precipitation increased with the rise of temperature. The precipitation concentration at 60 °C was significantly higher than the other two temperatures. Among them, the precipitation of 1# samples increased sharply with the increase of temperature. The Mo precipitation in sample 2# was very low at 20 °C and 40 °C, close to the detection limit, but there was obvious precipitation at 60 °C.
3.2. Pb/Cu precipitation in faucets for 10 days
In order to further study the heavy metal precipitation in the faucets with the increase of the number of extraction days, and the influence of temperature, the 3# samples was selected to continuously collect the extraction for 5 days in the next cycle, with lead, copper as the representative, to investigate its changes with the extraction days and temperature. As shown in Fig. 5 and 6, the precipitation of Pb/Cu did not significantly decrease with the increase of extraction days, and was affected by temperature similar to that of the previous 5 days, which the Pb increased significantly at 60℃, and Cu was more likely to be precipitated at 20℃ and 40℃.

![Pb Precipitation in 3# samples extracted for 10 days](image1)

Fig. 5. Pb Precipitation in 3# samples extracted for 10 days

![Cu Precipitation in 3# samples extracted for 10 days](image2)

Fig. 6. Cu Precipitation in 3# samples extracted for 10 days

Then, the precipitation of lead and copper in the three parallel samples of the 3# samples within 10 days was plotted separately, as shown in Figure 7. Overall, the precipitation trends of the three parallel samples were
4. Conclusions
In this study, by detecting the precipitation of Pb/Cu/Ni/Mo in the faucets at the extraction temperature of 20℃, 40℃ and 60℃, the results showed that the precipitation of heavy metals varied greatly among different batches of faucets. But in general, the Pb/Mo precipitation were the largest at 60℃ and the least at 20℃, which increases with the rise of temperature, Cu was the least at 60℃. While Ni precipitation was affected by the processing technology. The faucets without thorough cleaning had more Ni precipitation at higher temperature, and the faucets with low overall precipitation had more precipitation at 20℃.

Further investigation on the precipitation of Pb and Cu for 10 days showed that the precipitation of two heavy metals did not decrease with the increase of extracting days. Moreover, the precipitation concentration of different samples in the same batch was greatly different, which was mainly affected by the processing technology. In general, the precipitation of heavy metal in the faucets did not show a consistent trend with the temperature, and there were differences in the same batch of samples. However, the precipitation of Pb and Mo which have highly toxic increases with the increase of temperature. Therefore, quality and qualified water faucets should be selected in daily life, and the long-term water retained in the faucets (especially in high temperature environment) should be avoided as drinking water.

Acknowledgments
This research was supported by Quanzhou Science and Technology Project (Project No. 2018C093R).

References
[1] T.T. Huang, IOP Conf. Ser.: Earth Environ. Sci. 199, 032082 (2018).
[2] Z.H. Liang, X.W. Lian, X.X. Liang, et al., Chi. J. Heal. Lab. Tech., 17, 8, 1438-1439(2007).
[3] GB 18145-2014, Ceramic cartridge faucets [S].
[4] Z.X. Yang, Z.K. Ou, J.H. Zeng, World Nonferrous Met. 12, 168-171 (2016).
[5] Q.M. Ou, G.J. Zhu, W.K. Li, et al. Chem. Anal. Meter., 25, 1, 87-90(2016).