Historical forensics using hair analysis: Was Tycho Brahe murdered?

Nuclear analytical techniques played a pivotal role in helping to solve a high-profile historical forensics "cold case".

Tycho Brahe.
Figure credit: Janne Jönsson, Tycho Brahe Museum, Sweden.

Johannes Kepler is famous for his laws of planetary motion, one of the keys for the acceptance of the heliocentric model of the Solar system and for the emergence of modern science in the late 16th and early 17th centuries. His work built on Copernicus' heliocentric model, introducing elliptical planetary orbits, allowed for a much better explanation of experimental observations. But it was the Danish nobleman Tyge Ottesen Brahe, better known as Tycho Brahe, who had made 40 years' worth of accurate astronomical observations that Kepler used to derive his laws. In 1600, when Brahe was located at Prague as Imperial Court Astronomer of Rudolf II, Holy Roman Emperor, Kepler became his assistant. However, only after Brahe's death the 24 October 1601 did Kepler gain full access to his data, as he was appointed his successor.

Brahe's died on the 24th October 1601, after a short, 11-day lasting illness, following a banquet held by the Count of Rosenberg, where he held urine longer than usual, after which he could not urinate anymore. There are three contemporary accounts of the last days of Tycho Brahe, two of them describing symptoms of uraemia. The third account says that a stone was the cause, and that he died because his bladder burst. Although highly unlikely from the medical point of view, this account has become the most popular explanation of Brahe's death. Buried in the Church of Our Lady in front of Týn in Prague, Czech Republic, his tomb was first opened in 1901. Hair, beard-hair and funeral textile samples were then collected. In the 1990s a beard-hair and hair samples were analyzed with Atomic Absorption Spectroscopy (AAS) and micro-Particle Induced X-ray Emission (μ-PIXE). The detection of traces of mercury lead to suspicions of mercury poisoning. Even some speculations were developed that Tycho Brahe had been murdered with Kepler being one of the suspects.

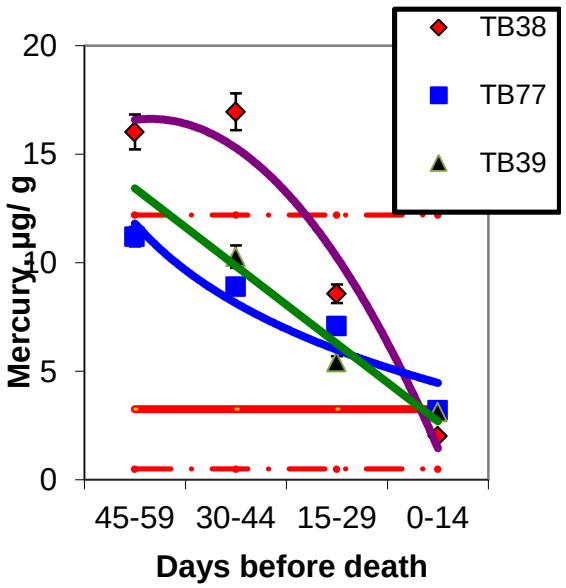
However, the μ-PIXE data were not quantified, and the Atomic Absorption Spectroscopy (AAS) data showed a mercury concentration of 6.20 μg/g (6.2 micrograms of mercury per gram of beard-hair), which was interpreted as very high but not uncommon to values found in the contemporary unexposed population.

Tycho Brahe's hair. Figure credit: Jan Kučera, Nuclear Physics Institute, Řež, Czech Republic

Tycho Brahe's tomb was opened a second time in 2010. Hair, bone and textile samples were again collected. Energy Dispersive X-ray analysis (EDX) experiments were done using a scanning electron microscope (L. Jonas et al., 2012). The measurements detected (but did

not quantify) mercury in the hair, and only in the hair scales, but not in the hair roots or shafts. The authors therefore ruled out mercury poisoning, and suggested that the origin of mercury could be an accumulation of mercury vapor at the surface of hairs due to Brahe's alchemistic activities.

However, EDX is only sensitive to large amounts of mercury, in the percent range, while the 1990s PIXE data showed concentrations thousands of times lower than that. Furthermore, the textiles found in the grave were treated with a mercury-containing compound, probably used in the embalming process, which could have caused surface contamination of the hair samples.



Mercury concentration in three different beard-hairs. Figure credit: Jan Kučera, Nuclear Physics Institute, Řež, Czech Republic.

In another study, hairs with identifiable root were selected for the determination of time-course of mercury concentrations. The hairs were cut in 5-mm long sections, each corresponding to around 15 days of growth. The section closest to the root is newly grown hair. The length of hairs available was around 2 cm, enough to determine a time-resolved mercury intake in the two months period before Brahe´s death. The hair sections were cleaned with the IAEA standardized procedure (IAEA 1978) and analyzed with radiochemical Neutron Activation Analysis (RNAA) at the Nuclear Physics Institute in Řež, the Czech Republic (K. L. Rasmussen et al., 2013), in a joint study with Danish scientists. RNAA is capable of determining selected elements at extremely low concentrations, down to sub-ng/g levels.

Three different hairs, both from the first (TB77) and second opening (TB38, TB39) of Brahe´s tomb were analyzed, with results that consistently showed that the mercury concentration decreased in Brahe's last two months. Two months before his death, the mercury concentration had been larger than the median found in populations nowadays. In any case, the values found (16 µg/g), are much below moderate mercury intoxication levels (200 to 800 µg/g) and therefore toxicologically insignificant. The researchers at Řež also analyzed two hair samples with µ-PIXE, the same technique as in the 1990s experiment, but this time in a quantitative manner. The results matched those achieved with RNAA, so that it could be concluded that Tycho Brahe did not die from acute mercury poisoning. Danish scientists from the University of Southern Denmark determined the mercury concentration in bone samples with AAS, and the values matched those found in healthy populations (K. L. Rasmussen et al., 2013). Thus, long-term chronical exposure to mercury could be excluded as well.

But still, why was Tycho Brahe's hair mercury concentration elevated two months before his death, and why did it decrease towards normal values later? The answer may lie in Brahe's alchemical activities, namely in the preparation of his famous elixir *Medicamenta tria*, which contained mercury (K. Figala, 1972). He might test it or self-administer it, which would lead to elevated mercury concentrations. If he had stopped taking it, the mercury concentrations would slowly decrease, similarly as stopping all other alchemical activities.

So, can we say today that Tycho Brahe was not murdered? No, since there is no way to test for other poisons. However, uraemia appears the most plausible explanation of Brahe's death.