Tiny fine particles of global impact – radiocarbon reveals the origin of black carbon

July 5 2018

A technical breakthrough was achieved in the source determination of very small carbon samples at the Accelerator Laboratory and the Laboratory of Chronology of the University of Helsinki. The development work is essential in climate research as it facilitates disentangling the origin of black carbon particles.

The ratio of modern biomass vs. fossil material present in any carbon containing sample can be determined by radiocarbon dating with a particle accelerator. The amount of the radioactive isotope of carbon (^{14}C, radiocarbon) is halved every 6,000 years, making fossil material entirely free of it.

In recent years, the method based on the half-life of radiocarbon has been used particularly in Finland to determine the proportion of biomass in fuels – in support of bioeconomy. Typically, particle accelerators require one milligram of solid carbon to quantify the very small amounts of radiocarbon contained in samples.

"The ratio of radiocarbon in carbon is one millionth of a millionth. We are not looking for a needle in the haystack, but for the needle tip on the entire farm," illustrates Markku Oinonen, director of the Laboratory of Chronology.

Half of a salt crystal enough for a sample

A project investigating the origin of black carbon, that is soot particles warming the climate, has succeeded in determining radiocarbon concentrations in samples that are as much as a hundred times smaller, only 10–20 micrograms of weight. The radiocarbon dating results of the tiny samples correspond well with results gained from solid carbon samples. This technological advancement is extremely valuable due to a general research trend towards increasingly smaller sample sizes.

"The method is based on a hybrid ion source that uses gaseous samples and a carbon dioxide feed system," explains Kenichiro Mizohata, a researcher at the Accelerator Laboratory.

Soot particles collected from the environment are chemically purified and combusted to carbon dioxide. The recovered carbon dioxide is then fed to the ion source for radiocarbon dating. Previously, a piece of solid carbon was required for radiocarbon dating but now the radiocarbon quantification can be performed directly on carbon dioxide, significantly reducing the needed amount of carbon.

"The soot samples analysed in the study are the size of half a salt crystal or one tenth of a poppy seed, in other words so small that the traditional determination method may not have worked on them without the development work on the gas ion source," reasons Antto Pesonen, quality coordinator at the Laboratory of Chronology.

Black carbon melts glacial ice

Black carbon effectively absorbs sunlight and thus accelerates the melting of glaciers. Soot is topical in international political discussions, and the University of Helsinki is a pioneer in the study of this global issue.

"Contrary to prior understanding, we have discovered that black carbon deposition has increased in the Arctic regions of Europe and western Russia in recent decades. Black carbon seems to contribute to the observed increased melting of Svalbard glaciers," explains Meri Ruppel, a researcher at the University of Helsinki.

The ongoing research project investigates the sources of Arctic black carbon, including industry, households, traffic and forest fires. Particular attention is paid to flaring emissions from the Russian oil and gas industry.

The radiocarbon dating of black carbon was carried out as multidisciplinary collaboration between the Laboratory of Chronology and the Accelerator Laboratory.

Provided by University of Helsinki