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Development of an isotopic biodosimeter to assess radon gas exposure

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The radioactive decay of radon in the home is the leading cause of lung cancer in non-smoking Canadians (REF 1,2). Radon produced by the decay of uranium and thorium minerals entering the home may accumulate in concentrations that exceed the national maximum guideline for indoor air of 200 Bq/m³. There is a critical need to develop a practical tool to assess an individual's exposure to radon and eventually one's lung cancer risk. An important opportunity is to use keratinizing tissues in the body (hair, nails) as archives of radon exposure. The lead is sequestered from the environment in toenails, including the relatively long-lived (22 yrs) ²¹⁰Pb isotope, which comes from ²²²Rn decay.

In this project, we are using isotope ratio mass spectrometry to quantify the amount of ²¹⁰Pb in a known amount of sample. This method has the advantage of providing a direct and relatively rapid count of the numbers of ²¹⁰Pb atoms. The challenge is that the actual number of ²¹⁰Pb atoms is very low and achieving reliable results requires high sensitivity methods specifically designed for the extraction of lead from the biological matrix. In the first stages of the project, we are using isotope dilution methods coupled with multiple collector inductively coupled plasma mass spectrometry (MC-ICPMS). Initial results demonstrate that femtogram quantities of lead can be measured.

The next stage of the project involves the design and construction of a laser ablation ion source coupled to the Multiple Reflection Time of Flight (MR-TOF MS) at the TITAN instrument at TRIUMF. The laser ion source in combination with the MR-TOF MS offers high sensitivity and the ability to separate isobars of ²¹⁰Pb. The laser beam, after passing through optical telescope system and polarizers for pulse energy modulation, is focused on a small point on the sample surface located in a high-vacuum chamber. Thus, the laser source enables spatial mapping of ²¹⁰Pb isotopic composition and allow one to map the accumulation of the radon daughter products over the growth of tissue. Ultimately, an accurate measurement of the number of accumulated atoms in an individual's biological tissue may be a personalized biodosimeter for radon.

1. Gogna, Priyanka, et al. "Estimates of the current and future burden of lung cancer attributable to residential radon exposure in Canada." Preventive medicine 122 (2019): 100-108
2. Stanley, F. K., Zarezadeh, S., Dumais, C. D., Dumais, K., MacQueen, R., Clement, F., & Goodarzi, A. A. (2017). Comprehensive survey of household radon gas levels and risk factors in southern Alberta. CMAJ open, 5(1), E255–E264. https://doi.org/10.9778/cmajo.20160142
3. Stanley, Fintan KT, et al. "Radon exposure is rising steadily within the modern North American residential environment and is increasingly uniform across seasons." Scientific reports 9.1 (2019): 1-17.

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