TO WHAT EXTENT WILL CYCLOTRONS IN FUTURE REPLACE REACTORS IN THE FIELD OF ISOTOPE PRODUCTION?

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Before Fission reactors were invented radioisotopes were produced using a Cyclotron. The subsequent wide accessability of Reactors led to their widspread use for "Medical Radioisotope" production. Cyclotrons have re-entered the scene in recent times producing 15 to 20 percent of Medical Radioisotopes in use. With uncertainties in the continued availability of reactor space Cyclotron driven substitutes or replacements are being planned. Political, social and environmental factors will probably determine whether these plans will need to be implimented.

In the late 1930's "artificial" radioisotopes were produced using Lawrence's early Cyclotrons in Berkeley. Some of these isotopes were utilised in pioneering biological investigations adding greatly to the previously available "naturally occurring" radioisotopic tools.

Being accelerator-produced these "new" radioisotopes were generally but not invariably neutron deficient.[1]

With the discovery of the neutron induced fission process and the subsequent assembly in the 1940's of controllable neutron fission "reactors" other radioisotope production routes based primarily on "neutron capture" were introduced, especially for the neutron-rich nuclides.

Because many research reactors were built in those early days for other initiatives, access to "cheap" surplus neutrons for radioisotope production lead to a rapid expansion into the use of "neutron-rich" radioisotopes for Medical and Industrial applications.

In contrast, the use of Cyclotrons for radioisotope production was limited to the few operational machines with a useful beam current, which could spare time out of their central program to provide charged particle beams for the Nuclear Physicists. The exception was the "Oak Ridge 86 inch"cyclotron. The magnet of this machine had served as part of an isotope mass separator for bulk ^{235}U production in the early 40's, when finally commissioned bore the brunt of cyclotron radioisotope production until the mid 1960's[2].

Commercial organisations acquired there own cyclotrons when a market was identified. Cyclotrons presently produce about 15 to 20 percent of the radioisotopes used in medicine.

There has recently been some uncertainty about the long term access to reactor space for radioisotope production as the reactors reach the end of their useful life[3].

Because of the increasing environmental pressures on new reactor initiatives there have been some serious re-thinking about the possibility of transferring the production of the key medical radioisotope $^{99}Tc^{m}$ to a cyclotron-based route.

Preliminary design studies have been carried out to explore the possibility of producing separated $^{99}Tc^{m}$ or $^{99}Mo/^{99}Tc^{m}$ with cyclotron based systems.

The first would involve the direct production of $^{99}Tc^{m}$ by the proton irradiation of enriched ^{100}Mo at regional centres strategically placed for good delivery logistics.[4,5]

The second more ambitious initiative involves the use of a cyclotron driven spallation neutron source with subcritical amounts of fissile material to provide neutron flux amplification to level suitable for production of $^{99}Mo/^{99}Tc^{m}$ using the standard ^{235}U fission process.[6] This would have many of the attributes of a reactor without being a critical assembly, and it could be turned on and off at will.

Another issue is whether the cyclotron-produced short lived positron-emitting radioisotopes ^{15}O,^{13}N, ^{11}C and ^{18}F used with Positron Emission Tomographic (PET) Imaging will begin to make a significant impact on the demand for $^{99}Tc^{m}$ based Nuclear Medicine procedures.

In the light of the increasing sensitivity of the public at large to the potential hazards of radionuclide based imaging procedures and the significant move towards non ionising imaging modalities using ultrasound and magnetic resonance the whole future of radioisotope production for medical imaging may be in question.

References

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