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## Application of monochromatic keV X-ray source to X-ray drug delivery system development

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### Summary

X-ray drug delivery system is the most advanced radiation therapy coming after IMRT (Intensity Modulated Radiation Therapy) and IGRT (Image Guided). DDS uses advanced nano-scaled polymers which contain and deliver drug or contrast agent to cancers without side effects. Several X-ray DDS poses high-Z atoms like Pt and Au to absorb X-rays effectively and used as contrast agent for inspection. Moreover, they have radiation enhancement effect by emission of Auger electron and successive characteristic X-rays. The enhancement factor of Pt and Au is more than five. This can be used for therapy. This new modality must be very important for inspection and therapy of deep cancers. We are making use of our Compton scattering monochromatic keV X-ray source for the purpose. Studies to evaluate the biological effect of the gold colloids have been carried out. The combinational effect of X-rays and colloidal gold has been evaluated from several points of view. DNA double- and single- strand breaks were measured with the gamma-H2AX focus assay and the alkaline comet assay, respectively; the cell toxicity was evaluated using the colony assay. Results obtained so far indicate that the combinational use of X-rays and colloidal gold does not enhance the toxicity. This implies that colloidal gold would be beneficial as contrast agent rather than a sensitizer during radiotherapy, which is also supported by numerical simulations showing that colloidal gold accumulated inside a tumor with a practical mass percentage provides contrast on the X-ray image as clear as bones. It should be noted, however, that this should depend on various other parameters such as the size of colloidal gold and the energy of irradiated X-rays. Further studies are in progress. Particle Induced X-ray Emission (PIXE) has been employed to measure the time transient of uptake of cisplatin micelle, which is the practical anti-cancer DDS containing Pt and shell-shaped polymer, into cells. The results showed that it is very likely that not cisplatin micelle itself but cisplatin released from the micelle is uptaken by the cells. Presently experiments using microbeam PIXE system have been carried out to evaluate the behavior of platinum-incorporated DDS drugs inside cells/organs. In addition to the above fundamental in-vitro experiments, numerical simulation of the imaging by the gold colloids by using our X-band Compton source is presented for coming experiments.

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