Plastic scintillator (PS) is a promising dosimeter for brachytherapy and other low-energy photon applications because of its high sensitivity and approximate tissue equivalence. As part of our project to develop a new PS material which maximizes sensitivity and radiological equivalence to water, we have measured the response, ε, (light output/unit air kerma) of PS to low-energy X-ray Bremsstrahlung (20 to 57 keV average energies) and Ir-192 spectra relative to an ion chamber with NIST-traceable calibration factors. The PS systems included BC400 and our new sensitive and quench-resistant scintillator (polyvinyltoluene base and bPBD/BBOT dyes) with and without 4% Cl loading intended to match the effective atomic number of water. For BC-400 irradiated by low-energy X rays, ε was 20%-57% relative to Ir-192. Adding chlorine loading clearly reduced the energy dependence of ε, which ranged from 42% to 85% relative to Ir-192. However, even after using Monte Carlo simulation to correct for the non-air equivalence of PS, inherent dosimetric sensitivity still varied by 45% over the 20-400 keV energy range. Our work, one of the few measurements of PS response to low-energy photons, appears to confirm Birk's 1955 finding that ionization quenching reduces sensitivity to electrons below 125 keV. Our results can not be explained by the conventional unimolecular quenching model.
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