§22. Investigation on Environmental Behavior of Organically Bound Tritium

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OBT (Organically Bound Tritium) which are produced by plants through photosynthesis plays a key role in radiation exposure to tritium because vegetables are mine food stuff for us. OBT in vegetables as well as water occupies a considerable fraction of tritium intake in man.[1] The OBT can be defined by two fractions: the exchangeable fraction and the non-exchangeable fraction. Exchangeable OBT is the labile site of organics for hydrogen in plants, and is in isotopic equilibrium with free water of plants and thus reflects tritium level of the local atmospheric moisture and soil water. By contrast, non-exchangeable OBT is directly bound to carbon atom, and no longer follows the local environmental hydrogen isotope composition change. It would represent an integration of the environmental tritium level during the growing periods.

Hydrogen of water in leaf is used in photosynthesis to produce carbohydrate. Two kinds of water sources are considered for leaf water; one is soil water and the other is atmosphere water vapor. Of course transpiration of soil water is the main water flow in plant that moves water from root zone to atmosphere. However, tritium flow in plants depends on tritium distribution condition. For example if tritium concentration is higher in atmosphere water vapor than leaf water, tritium moves from air to leaf under active transpiration condition.

To investigate tritium incorporation into carbohydrates by photosynthesis at different tritium distribution condition, we carried out incorporation experiments using DHO. Fully expanded peppermint was cultured in DHO solution in a conical beaker for 24 h in controlled condition. During the 24 h exposure to DHO solution fresh air were always supplied to the peppermint to remove water vapor released from the leaf and direct evaporation of DHO solution was prevented by sealing of the mouth of the conical beaker. Before culture, the peppermint was kept in dark for 24 h to exhausting all carbohydrates produced previous light condition. The newly produced carbohydrates during exposure to DHO solution were recovered as follows. The leaf was dried and crashed. The carbohydrates in dry leaf were extracted with 80% ethanol solution and purified with charcoal. The purified carbohydrates would be mostly monosaccharide and disaccharide. The carbohydrates synthesized under DHO exposure condition were oxidized and hydrogen isotopes were obtained as water. The deuterium concentration in water was analyzed by gas chromatography. The deuterium concentrations in culture solution, leaf water and carbohydrates are shown in Table I. The deuterium concentration in the culture solution was 11.2 % which was decreased to 7.4 % in leaf after 24 h exposure. It has been reported that deuterium concentration in leaf water is always lower than in the culture solution even if long exposure time was taken, which is recognized as dilution effect by atmospheric water.[2] As mentioned before the major water flow by transpiration is from plant to atmosphere, however because of the concentration graduation of deuterium between air and leaf water, the deuterium moves much faster from leaf to atmosphere resulted in lower concentration of leaf water than that of the culture solution. Plant uses leaf water as the source of hydrogen in photosynthesis, and then we can expect 7.4 % deuterium concentration for the produced carbohydrate. The deuterium concentration observed in carbohydrate was only 0.5 % which is very low even if we take into account the isotopic discrimination effect.

Table I Deuterium concentrations

	Deuterium (%)
Culture solution	11.2
Leaf water	7.4
carbohydrate	0.5

Plant takes atmospheric CO_2 through stoma into intercellular space due to CO_2 concentration gradient. The CO_2 permeates the cell wall of palisade and spongy tissues and reaches to chloroplast which is located near the cell wall to make easy access to CO_2. We speculate that the deuterium concentration adjacent to the cell wall differ from that of the leaf water which was obtained as an average value. Under the present experimental condition the deuterium concentration of water available to chloroplast would be low because the chloroplast attaching to the cell wall is placed in the circumstance that the deuterium concentration gradient is larger than other part of the cell. To confirm this hypothesis we plan experiment that the source of deuterium is atmospheric water vapor.

1) UNSCEAR: Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation (2000).
2) Momoshima et al: "Uptake kinetics of deuteriated water vapor by plants: Experiments of D_2O release in a greenhouse as a substitute for tritiated water." *J. Radioanal. Nucl. Chem.*, 239, 459-464 (2006).