2.Polystyrenes

Polystyrenes, because there are light in weight and easy to mold, and have high adiathermancy and buffer effect, have been used in food containers, household appliances and building materials (heat insulators). Polystyrenes are generally formed by repeated polycondensation, of styrene monomers obtained via ethylbenzene made from ethylene and benzene. Styrene monomers, styrene dimers and styrene trimers, present in polystyrene resin as reaction intermediates and degradation products, are suspected of being endocrine disruptors.

●Annual food-related use (investigated by Japan Hygienic Olefine and Styrene Plastics Association, unit: 1,000 ton)

Production: 1,504; export: 403; domestic sales: 1,101, including food-related use: 40

(1) Elution of styrene monomer, styrene dimer and styrene trimer

Standard polystyrene contains 400 to 1,000 ppm of styrene monomer, 400 to 1,000 ppm of styrene dimer and 2,500 to 8,000 ppm styrene trimer, whose values vary according to production method[*111]. Elution of these chemicals from tableware has been studied at the National Institute of Hygienic Sciences and other facilities. As shown in Table 2, elution volumes were appropriately 1 ppb to 1 ppm for monomer, below 1 ppm for dimer and below 100 ppm for trimer; there are many other reports below the detection limit[*112*113*114*115*116*117]. N-heptan (mimicking solvent for oils, fats and lipo-soluble foods), 4% acetic acid (mimicking solvent for water-soluble and acid foods), ethanol (mimicking solvent for alcoholic beverages) and water (other foods) were used as elution solvents. The elution volumes with n-heptan were relatively high.

Styrene monomer content was determined for 12 kinds of foods, such as wheat, peanuts, etc.; styrene was detected in 8 of them, at values of a few ppb, except for cinnamon, with 39,200 ppb[*118].

(2) Safety of Styrene monomer, styrene dimer and styrene trimer

1. Screening

- In vitro study

In vitro action of styrene monomer, styrene dimer and styrene trimer have been reported as follows: in the study to investigate estrogenic activity using proliferation potency of MCF-7 (human mammary carcinoma cell line) as an index, styrene monomer was found not to have estrogenic action[*119].

(Reference data)

(a) In estrogenic and androgenic receptor-binding capacity studies for styrene dimer (3 types) and trimer (3 types) using rat uterine cytosolic fraction, binding capacities were infinitestimal[*101].

(b) In a study on styrene dimer (10 types) and trimer (3 types) to examine proliferation potency using MCF-7, proliferation potencies were not observed[*101].

- In vivo study

A simple and representative in vivo method currently used to quickly evaluate the estrogenic action of chemicals involves administering chemicals to rodents such as rats and weighing the increase in uterine weight. Results of styrene dimer and trimer studies have been described in some company journals. Though the results should be examined in detail after the publication of papers, we show these data for reference as follows:

(Reference data)

(a) In utero-trophic assays for styrene dimer (3 types) and trimer (3 types) at doses of 20 and 200 mg/kg (once a day for 3 days) subcutaneously to rats, there was neither increase in uterine weight nor histopathological change[*101].

(b) In a study in female rats fed a mixed diet for 4 days, using low molecular weight polystyrene, mainly composed of styrene tetramer (10, 20, 40, 80 and 160 ppm), increase in uterine weight was seen in 160 ppm (27.9 mg/kg) group, a figure considered to be 1/20,000 of that of DES as positive control[*120].

(c) In a single-dose study in female rats aged 22 days inbjected peritoneally (100, 300 and 1,000 mg/kg) with by-products in polystyrene production (dimers: 0.94%; trimers: 69.5%), premature vaginal opening was found in 1,000 mg/kg group[*121].

(d) In a study in SD rats orally administered with polystyrene extracts in 50%

ethanol ([1] mixture of dimer (<0.05 ppm) and trimer (3 ppm); [2] mixture of dimer (<0.01 ppm) and trimer (0.6 ppm)) for 4 days, there was no increase in uterine weight[*122].

2. Repeat dose toxicity study

Toxicity of styrene monomer has been reported as follows:

In a 3- to 4-month repeat inhalation study in rats with styrene (5 and 50 mg/m^3), prolonged estrous cycle was observed[*123].

(Reference data)

In a 2-year combined chronic toxicity and carcinogenicity study in rats with styrene inhalation (50, 200, 500 and 1,000 ppm), no carcinogenicity was observed[*124].

3. Epidemiological studies

Female workers exposed to styrene at a high concentration were investigated. Results are as follows:

1) In 30 female workers at a glass-fiber-reinforced boat factory (average: 28.6 years of age; exposure: 130 ppm for 6.2 years (US Government Occupational Health Council Recommendation: 50 ppm)), the serum prolactin level was twice that of controls, and correlated with urine excretion of styrene metabolites. The growth hormone level was also high[*125].
2) In 16 female workers exposed to styrene (average: 24.4 years of age; exposure: 5 years), 200 μg of thyrotropin-releasing hormone (TRH) was injected and serum prolactin (PRL) levels at 10, 20, 30, 45, 60 and 90 minutes after injection was determined. PRL levels at 10, 20, 30 and 45 minutes were higher than the upper limit of the normal range[*126].

(3) Conclusion

Reportedly, styrene monomer, styrene dimer and styrene trimer have neither proliferation potency against MCF-7 (human mammary carcinoma cell line) nor ER-binding capacity, though the latter information was reference data. However, chemicals suspected of being endocrine disruptors include tributyltin, which expresses its action by enzyme inhibition, and dioxin, which expresses its action by binding to other receptors. Possible endocrine-disrupting actions like these

therefore cannot be ruled out.

In utero-trophic assay for styrene dimer (3 types) and trimer (3 types) in rats, there was neither uterine weight increase nor histopathological change, and estrogenic action was considerably lower than that of estradiol, although these are reference data.

As shown above, we do not have scientific findings that styrene monomer, dimer and trimer, at the levels eluting from polystyrene, seriously affect human health; therefore, it would not be necessary to prohibit the use of polystyrene at present.

(4) Future research

- Concentration research in human umbilical cord blood and breast milk
- Research for elution volumes from tableware