

Probing Legacy and Alternative Flame Retardants in the Air Of Chinese Cities

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An increasing number of alternative flame retardants (FRs) are being introduced, following the international bans on the use of polybrominated diphenyl ether (PBDE) commercial mixtures. FRs production capacity has shifted from developed countries to developing countries, with China being the world's largest producer and consumer of FRs. These chemicals are also imported with e-waste to China. Therefore, it is important to understand the current status of regulated brominated FRs, their phase-out in China, and their replacement by the alternatives. In this study, a broad suite of legacy and alternative FRs, including eight PBDEs, six novel brominated FRs (NBFRs), two dechlorane plus variants (DP_S), and twelve organophosphate FRs (OPFRs) were evaluated in the air of 10 large Chinese cities in 2018. OPFRs are the most prevalent FRs in China, exhibiting a wide range of 1-612 ng/m³, which is several orders of magnitude higher than PBDEs (1-1827 pg/m³) and NBFRs (1-1428 pg/m³). BDE 209 and DBDPE are the most abundant compounds in brominated FRs (>80%). The North China Plain (NCP, excluding Beijing), Guangzhou, and Lanzhou appear to be three hotspots, although with different FR patterns. From 2013/2014 to 2018, levels of PBDEs, NBFRs and DPs have significantly decreased, while that of OPFRs has increased by one order of magnitude. Gas-particle partitioning analysis showed that FRs could have not reached equilibrium, and the steady-state model suits better for FRs with higher log K_{OA} (>13). To facilitate a more accurate FRs assessment in fine particles, we suggest that, in addition to the conventional volumetric concentration (pg/m³), the mass-normalized concentration (pg/g PM_{2.5}) could also be used.