BIOANALYTICAL APPROACHES TO POPS DETECTION

Michael S. Denison
University of California, Davis, USA

Proper epidemiological, risk assessment and exposure analysis of persistent organic pollutants (POPs) requires accurate measurement of specific chemicals or classes of chemicals both in the species of interest, but also in various exposure matrices (i.e. biological, environmental and food). Although high resolution instrumental analysis techniques are established for many of these chemicals (i.e. polychlorinated dibenzo-p-dioxins (PCDDs), biphenyls (PCBs) and dibenzofurans (PCDFs), polycyclic aromatic hydrocarbons, chlorinated pesticides, brominated flame retardants, etc.), these analytical procedures generally require highly sophisticated equipment and training and are also very costly and time-consuming. The high cost of these analysis not only makes large scale sampling studies impractical (such as that which occurs in epidemiological studies and in assessment of areas with widespread contamination), but often the experimental design of many of these studies tends to become driven by the budgetary constraints for sample analysis. To complicate issues, many environmental contaminants still remain to be identified (i.e. endocrine disruptors) and high resolution analysis methodologies for many others still remain to be developed and validated. Additionally, often the concentration of a single chemical in a given complex mixture of chemicals provides only part of the information necessary to evaluate their potential for biological/toxicological effects in humans and animals.

Bioanalytical and bioassay methods can provide an inexpensive and rapid alternatives in which to detect and/or estimate the relative biological/toxic potency of individual POPs or complex mixtures containing POPs. Bioanalytical methods are generally based on the ability of a chemical(s) to be specifically recognized and bound by antibodies (immunoassays) or their ability to induce a specific biological response in vitro or in cells in culture (bioassays). Immunoassay-based bioanalytical approaches utilize reagents (antibodies) which are generated against a specific chemical structure and as such, they tend to be relatively specific for a given chemical or closely related chemicals. Although false positives generated as a result of cross-reactivity to other structurally-related chemicals are the major negative feature of this type of biological-based assay, the specificity of antibody recognition can be determined. Even given this drawback, a significant advantage of the immunoassay approach is that with the inclusion of proper controls, it is very difficult to obtain false negatives. As such, even though these assays are not as sensitive as other bioanalytical approaches, immunoassays techniques can be used to screen out large numbers of negative samples prior to instrumental analysis. Bioassay approaches for chemical detection are generally less specific than immunoassay approaches and they are based on the ability of a chemical or chemical class to affect a specific biological response or pathway. Receptor-based bioassay systems are currently the most widely used systems for chemical detection and they are based on the ability of a chemical (ligand) to bind to the receptor and stimulate receptor-dependent gene expression in cells in culture. Receptor based-cell bioassays have been developed to detect PCDDs, PCDFs, PCBs and related POPs (using the Ah receptor pathway) as well as chemicals

which can act as environmental hormones (using steroid hormone receptor pathways). These cell bioassays are rapid, sensitive, relatively inexpensive and easy to conduct. In addition, for some of these cell bioassays (i.e. the AhR cell bioassay), numerous validation studies have already revealed an excellent quantitative correlation between receptor-dependent induction of gene expression induction and chemical (TCDD/HAH) detection as determined by instrumental analysis. Thus, bioanalytical techniques can be used effectively to detect specific POPs.

Numerous studies have demonstrated that numerous bioanalytical methods can be used as valid approaches for the rapid and inexpensive detection and relative quantitation of a variety of POPs and/or the identification of novel POPs. However, even given the advantages of bioanalytical approaches, these methods have not gained widespread use and this likely results from the lack of regulatory acceptance of these new methods. Although these bioanalytical methods have been in place for years, they are only now being examined in detail and considered as screening methods. The availability of fully-validated and accepted alternative bioanalytical methods for POPs detection and analysis will greatly facilitate many large scale screening studies where the equipment and/or funding is limited (as it usually is). The results and process necessary to gain regulatory acceptance of these alternative bioanalytical methods are critical issues that need to be resolved.