different oligonucleotides are grafted on polyacrylamide fibers. In the presence of a third aptamer, the oligonucleotide-fibers are linked and the formation of the gel stops the sample flow. If a target molecule is present, it forms a complex with the aptamer, subsequently inhibiting gelation. Thus, the sample continues to flow, indicated by food dye which is dragged along. The system was used for the qualitative detection of lead, cocaine, and adenosine.

Whole cell biosensors

In tissue engineering and three dimensional cell studies, different cell types are trapped and cultured in hydrogel scaffolds. Some of these cell cultures have been utilized as biological detectors. Microbial cell-based biosensors have been especially developed for the determination of pollutants in environmental samples and for process monitoring in the food industry (Banerjee et al. 2010). Genetic engineering of microbes for enzyme, and fluorescent protein expression allows the design of versatile biosensors. As an example, green fluorescent protein (GFP) expressing bacteria constitute self-contained sensors in toxicity assays. Engineered yeast cells were immobilized in gelatin for ready-to-use assays of estrogenic activity of environmental samples. The assay was based on estrogen receptor-mediated luminescence of living yeast cells upon exposure to samples without any pre-treatment. Gelatin enabled a superior assay performance over agar gels and showed stable results for 90 days (Bittner et al. 2015). In addition to yeast and bacteria, microalgae have been incorporated in biosensors. Algae are sensitive to environmental changes and can be employed to detect herbicide and heavy metal concentrations. A simple and effective readout is based on the altered chlorophyll fluorescence by these compounds (Ferro et al. 2012).

In addition to microorganisms, mammalian cell lines have been employed in three dimensional gel matrices for the detection of food borne pathogen toxins, viruses, and disease markers by antibody binding (Banerjee et al. 2013). For a simplified readout, the activity of released enzymes from toxin damaged cells can be determined by a color change. This concept was validated with a series of complex food samples and non-toxic background flora (Banerjee et al. 2010). A drawback of mammalian cells in biosensors is the limited shelf life, preventing their extended use in devices for field applications. However, microarrays of gel-encapsulated cells have been proposed for high-throughput multiplexed toxicological assays and drug screening in standard laboratories. These assays mainly use robotic fluid dispensing to spot cellular microhabitats on functionalized surfaces (Berthuy et al. 2016).

Gel membranes for size exclusion and flow control

Flow control and separation of biological species are important sub-tasks in sensing and diagnostic procedures. The degree of freedom in pore size tuning enables hydrogels to be ideal candidates for molecular flow control and size exclusion. As previously mentioned, one of the most important applications of hydrogel membranes is the separation of proteins and nucleic acids in an electric field by size, namely gel electrophoresis. Besides the laboratory-based setups, many miniaturized gel membranes have found their way in sensing applications. A miniaturized electrophoresis system