Mixture effects on permeaiton of polyethylene pipes

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Summary

Nederlands: Verontreinigingen zijn vaak aanwezig in mengsels in de ondergrond, wat de vraag opwekt over synergetische effecten van chemische mengsels op de permeatie in polyethyleen (PE) –pijpleidingen. Een eerste literatuuronderzoek werd uitgevoerd naar de effecten van chemicaliën in mengsels en de permeatie in PE-materiaal. Uit de literatuur zijn twee situaties afgeleid voor vloeistof-PE-permeatie; waterige mengsels van chemicaliën en geconcentreerde (niet-waterige) mengsels. Voor waterige mengsels werden geen synergistische effecten waargenomen in de literatuur. Voor geconcentreerde chemische mengsels, zoals zuivere benzine, werden synergistische effecten waargenomen wanneer chemicaliën aanwezig waren in binaire of multi-componenten mengsels.

English: Contaminants are often present in mixtures in the subsurface which raises the question of synergistic effects of chemical mixtures on the permeation in polyethylene (PE) pipelines. A limited literature search was done on the effects of chemicals in mixtures and the permeation in PE material. From the literature two situations were derived for liquid-PE permeation; aqueous mixtures of chemicals and concentrated (non-aqueous) mixtures. For aqueous mixtures, no synergistic effects were observed in the literature. However, for concentrated chemical mixtures, such as pure gasoline, synergistic effects were observed when chemicals were present in binary or multi-component mixtures.

Contents

1 Background and Literature Search

Contaminants are often present in mixtures in the subsurface which raises the question of synergistic effects of chemical mixtures on the permeation in polyethylene (PE) pipelines. A limited literature review of the Scopus, Web of Science and Google Scholar databases was performed to find studies related to the effects of mixtures of contaminants on chemical permeation in PE. Most studies concerned the permeation of high density polyethylene (HDPE) geomembranes which are commonly used as landfill liners. The literature can be divided into two categories; those examining PE in contact with aqueous solute mixtures and those in contact with concentrated solute mixtures (non-aqueous). The mechanisms governing the permeation, diffusion and partitioning differ between dilute and concentrated solutions.

2 Aqueous Mixtures

In situations where PE is in contact with an aqueous mixture, individual chemicals will partition from the aqueous phase to the PE phase independently of the presence of other chemicals in the mixture. This has been shown by Park et al. (2012), who studied the partitioning of dilute single and multi-solute mixtures to HDPE and found no synergistic effects for most components. Similarly, Joo et al. (2004) found that the presence of other organic compounds in a dilute aqueous mixture had no effect on the partitioning to an HDPE geomembrane. Presad et al. (1994) found no synergistic effects of aqueous mixtures of TCE and toluene on the diffusion through an HDPE membrane when present in individually or in a mixture. In summary, based on the limited literature review no synergistic effects of chemicals in mixtures on the permeation of PE pipes is expected at the concentrations present dissolved in groundwater.

3 Concentrated Mixtures

When PE is in contact with concentrated mixtures then the permeation process is more complex. Park and Nibras (1993) performed experiments with neat (non-aqueous) single and multi-component mixtures. The authors found that the partitioning coefficient for the mixture could be calculated by summing the the single component partitioning coefficient multiplied by the mole fraction of the component in the mixture. However, the diffusion coefficient could not be similarly calculated. Friess et al. (2009) found a coupling effect of concentrated binary mixtures of components on facilitating transport through polymers; the presence of toluene increased the flux of heptane when present in a mixture. Other important considerations when concentrated mixtures are in contact with PE pipes includes swelling, the degree of cross-linking and crystallinity of the membrane and temperature, therefore it is not a simple relationship.

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