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Anionic Polyacrylamide

Environmental Profile

Anionic polyacrylamide is the generic name for a group of very high molecular weight macromolecules produced by the free-radical polymerization of acrylamide and an anionically charged co-monomer, mainly the sodium salt of acrylic acid, sodium acrylate. The combination of molecular weight and ionic charge results in extremely viscous aqueous solutions, one of the main properties of these polymers. Both the charge density (ionicity) and the molecular weight can be varied. By varying the acrylamide/anionic monomer ratio, a charge density from 0 to 100% along the polymer chain can be obtained. The molecular weight is determined by the type and concentration of the reaction initiator and the reaction parameters.

Anionic polyacrylamide has no systemic toxicity to aquatic organisms or microorganisms. The polymer is much too large to be absorbed into tissues and cells. The functional anionic groups do not interfere with the functioning of fish gills or daphnia respirators. Any adverse effects observed in laboratory tests are always seen at concentrations of over 100 mg./l and are probably due to the resulting viscosity of the test medium. The preparation of the test solutions at such concentrations requires high energy stirring for long periods of time, sometimes several hours. Therefore, it can be concluded that these harmful concentrations will not exist in the natural environment.

The test data given in this document was obtained using a highly charged anionic polyacrylamide. Low charge density polymers demonstrate even lower toxicity to aquatic and micro-organisms. The results of assays on anionic polyacrylamides are determined mainly by the viscosity of the test solution.

Anionic polyacrylamide has no potential to bioaccumulate, being completely soluble in water (solubility is only limited by viscosity) and insoluble in octanol. Additionally, being a flocculant, it adsorbs onto suspended matter and, in this way, is removed from the water phase.

The sensitivity of polyacrylamide to ultra-violet light is well known and has been described in the scientific literature. Photolysis leads to the degradation of the polymer chain and the formation of much smaller molecules, or oligomers, which are accessible to

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microbial attack. A recent study demonstrated that photolysis followed by aerobic or anaerobic treatment resulted in efficient mineralization of the polymer. This study provides evidence that acrylamide polymers have the potential to be naturally broken down and biodegraded and do not persist or accumulate in the environment.

Two recently conducted, major environmental risk assessments concluded that anionic polyacrylamide does not represent a danger to the environment. STOWA, the Netherlands Waste-Water Authority calculated a PEC/NEC ratio much lower than 1 for organic polyelectrolytes in general and concluded that their use in waste-water treatment does not constitute a risk to the natural environment. Another review of polyelectrolytes by Environment

Agency of the United Kingdom concluded that anionic polyacrylamide, like the other organic polyelectrolytes, is not a priority for the sensing of environmental quality standards (EQS) and of little environmental concern.

Chemical Identity

Chemical name: 2-propenic acid, sodium salt polymer with 2-propenamamide

Other names: Copolymer of acrylamide and acrylic acid, sodium salt Acrylamide, sodium acrylate copolymer

CAS number: 25085 - 02 - 3

Physical Chemical Properties

Molecular weight: greater than 1,000,000 Daltons, usually greater than 5,000,000

Solubility: totally miscible in water, insoluble in nectanol and other solvents

pH: 6 to 8 in solution at 5g/L

Apparent density; 1.08

Melting point: > 150C

Aquatic Toxicology

A. Toxicity to fish

LC50/ Brachydanio rerio/96 hrs. 357 mg/l

LC0/ Brachydanio rerio/96 hrs. 178 mg/l

B. Toxicity to daphnia

EC50/Dapbnia Magna/48 hrs 212 mg/l

C. Toxicity to algae

EC50/Chlorella vulgaris/96 hrs 1,000 mg/l

No Observed Effect Concentration 708 mg/l

D. Toxicity to bacteria

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EC10/Pseudomonas putida/18 hrs.	127 mg/l
EC50/Pseudomonas putida/18 hrs.	892 mg/l

ENVIRONMENTAL DATA

A. Bioaccumulation

Anionic polyacrylamide being totally soluble in water and insoluble in solvents has a very low n-octanol/water partition coefficient (POE), and for all practical purposes:

$$\log P_{OW} = 0$$

Thus, the potential for anionic polyacrylamide to bioaccumulate is zero.

B. Abiotic degradation (photolysis)

Anionic polyacrylamide is sensitive to ultra-violet light, which breaks down the polymer backbone into oligomers. A positive correlation is observed between the length of exposition to light and the degree of breakdown (i.e., reduction in molecular weight).

C. Biodegradation

Non-degraded anionic polyacrylamide has been shown to be recalcitrant to microbial degradation. This is probably related to the extremely high molecular weight, which renders microbial attack very difficult. However, once the polymer has been degraded through photolysis (i.e., the action of UV light), and the macromolecule broken down into oligomers, it becomes bioavailable and is biomineralized.

A study using C14 labeling, designed to evaluate the potential to biodegrade anionic polyacrylamide demonstrated that a combination of photolysis and microbial attack leads to natural attenuation of these polymers. After 48 hours of exposure to UV, the oligomers (MW < 3,000 Daltons) increased from under 2% to 80%. This enabled after 38 days incubation for the polymer to be biodegraded at least 29% aerobically and 17% anaerobically.

D. Residual Monomers

We take the utmost care to ensure that the constituent monomers (in this case acrylamide and sodium acrylate) are as completely reacted as possible during polymerization.

However, technically unavoidable traces can and do remain in the finished polymer, especially in powder products. For standard products, our quality assurance guarantees that polyacrylamides contain less than 0.1% w/w (< 1000 ppm) of residual acrylamide monomer and less than 0.5% w/w (< 5000 ppm) of residual sodium acrylate. In fact, on average, there is about 0.04% (400 ppm) of residual acrylamide and about 0.2% (2,000 ppm) of residual sodium acrylate.

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Both acrylamide and sodium acrylate are readily biodegradable under aerobic conditions at over 90% in 28 days. Even at operating doses as high as 50 mg/l, the residual monomers released into the environment will never reach concentrations that could constitute a risk to the aquatic life. Their high biodegradability negates the possibility of accumulation in the natural environment.

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