Floerger™ AN 900 series

Anionic polyacrylamide

Environmental data

Environmental profile

Anionic polyacrylamide is the generic name for a group of very high molecular weight macro-molecules produced by the free-radical polymerization of acrylamide and an anionically charged comonomer, 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 micro-organisms. 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. Therfore, it it can be concluded that these harmful concentrations will not exist in the natural environment.

The test data given on page 4 of 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 low anionic polyacrylamides is 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 flocculent, it adsorbs onto suspended matter and, in this way, is removed from the water phase. ***(cont.)***

Environmental profile (cont)

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 microbial attack. A recent study financed by SNF-Floerger, has 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 polyacrylmide, like the other organic polyelectrolytes, is not a priority for the setting of environmental quality standards (EQS) and of little environmental concern.

Physico-chemical properties

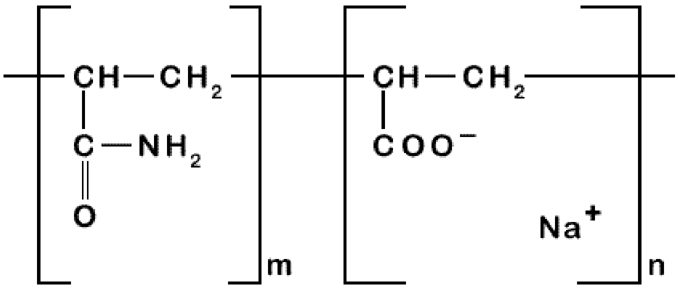
A. Chemical identity

Chemical name : . . . . . . 2-propenoic acid, sodium salt polymer with 2-propenamide

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

CAS number : 25987-30-8

B. Molecular structure



Anionic polyacrylamide: copolymer of acrylamide and acrylic acid, sodium salt

C. Physico-chemical properties

Molecular weight : . . . . greater than 1,000,000 daltons, usually greater than 5,000,000

Solubility : . . . . totally miscible in water, insoluble in n-octanol and other solvents

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

Apparent density : . . . . ~ 1.08

Melting point : . . . . > 150°C

Log P_{ow} : 0

Aquatic toxicology

A. Toxicity to fish

SNF test F242 : OECD 203 / GLP / Report dated December 21, 1995

LC50 / *Brachydanio rerio* / 96 hours	=	**357 mg/L**
LC0 / *Brachydanio rerio* / 96 hours	=	**178 mg/L**

B. Toxicity to daphnia

SNF test F243 : OECD 202 / GLP / Report dated December 21, 1995

EC50 / *Daphnia magna* / 48 hours	=	**212 mg/L**

C. Toxicity to algae

SNF test F244 : OECD 201 / GLP / Report dated December 21, 1995

$EC50_A$ (I) / *Chlorella vulgaris* / 96 hours	>	**1,000 mg/L**
$EC50_\mu$ (I) / *Chlorella vulgaris* / 96 hours	>	**1,000 mg/L**
No Observed Effect Concentration (NOEC)	=	**708 mg/L**

D. Toxicity to bacteria

SNF test F245 : OECD 301F, DIN 38412-27, ISO 7027 / GLP / Report dated December 21, 1995

EC10 / *Pseudomonas putida* / 18 hours	=	**127 mg/L**
EC50 / *Pseudomonas putida* / 18 hours	=	**892 mg/L**

Environmental fate

A. Bioaccumulation

Anionic polyacrylamide being totally soluble in water and insoluble in solvents has a very low octanol/water partition coefficient (P_{ow}), 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 labelling, 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 oligomer (MW < 3,000daltons) 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.

Residual monomers

SNF takes the utmost care to ensure that the constituant 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. Quality assurance guarantees that all Floerger 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.

Both of these substances are readily biodegradable under aerobic conditions at over 90% in 28 days. They also have very low aquatic toxicity except in the case of sodium acrylate to algae. However, it can be seen from the data in the tables below that even at operating doses as high as 10 mg/L, the residual monomers released into the environment will never reach concentrations which could constitute a risk to the aquatic life. The high biodegradibility negates the possibilty of accumulation in the natural environment.

	LC 50/fish/96 h.	EC 50/daphnia/48 h.	EC 50/algae/72 h.
Acrylamide	> 100 mg/L	> 100 mg/L	34 mg/L
Sodium acrylate	> 100 mg/L	54 mg/L	3.5 mg/L

Aquatic toxicity of acrylamide and sodium acrylate

	Acrylamide	Sodium acrylate
Biodegradation in 28 days (OECD 301C)	95%	95%

Biodegradability of acrylamide and sodium acrylate

	Acrylamide	Sodium acrylate
Use level = 10 mg/L	< 10 µg/L	< 50 µg/L
% of lowest LC50 or EC50	0.16	1.6

Environmental risk of acrylamide and sodium acrylate