

Executive Summary of Biodegradation Studies

3M has completed a series of studies of the biodegradability of various fluorochemical materials based on EPA Guidelines OPPTS 835.3200, OPPTS 835.3210 and/or OPPTS 835.5045. The purpose of these studies was to provide information regarding the biodegradability of these materials by aerobic microorganisms present in municipal wastewater treatment sludge. This information aids the understanding of the environmental fate of Perfluorooctanesulfonyl based chemistries.

Table 1 lists materials studied and their chemical abbreviations as well as report identification numbers. The studies are GLP-like; many GLP standards were used in the studies, and the quality assurance procedures followed were based on the practices described in the GLP documentation (40 CFR Part 792, TSCA).

Studies included the preparation of replicate sample cultures containing a mineral salts medium, an activated sludge inoculum and the test substance. Additionally, blank sludge controls, sterile/inhibited controls, positive controls, matrix spikes and blanks were used as appropriate to evaluate analytical results. After incubation for specific times, fluorochemical species were extracted from test cultures utilizing solid phase extraction. HPLC/MS techniques provided identification and quantitation of the test substance and degradation products. Molar mass balance was achieved indicating that all significant degradation products were identified.

This series of studies began with a 35-day study to identify the biodegradation products of N-EtFOSE alcohol. Based on the results of the 35-day N-EtFOSE alcohol biodegradation test, a second 18-day study was conducted to evaluate the biotransformation of each of the individual N-EtFOSE alcohol degradation products. N-EtFOSE alcohol was also re-tested in this study. These results are reported separately. Generally, the results of this second 18-day study were consistent with the 35-day N-EtFOSE alcohol study.

In the follow-up studies, 9.3 % of the N-EtFOSAA was biotransformed over the course of 18 days to yield measurable quantities of M556, FOSA, PFOS and PFOA.

N-EtFOSA was biotransformed into M556, FOSA, PFOSulfinate, PFOS and PFOA. However, only 30-35% mass balance was attained.

The compound M556 showed biotransformation to FOSA (major product), PFOSulfinate, PFOS and PFOA. After the 18-day incubation, 74% of the parent material remained in samples containing sludge with excellent mass balance.

As expected, FOSA was biotransformed to PFOSulfinate, PFOS and PFOA. 90% of the parent remained after incubation. Mass balance was excellent.

PFOSulfinate formed PFOA in the abiotic controls. Samples of PFOSulfinate that contained active sludge formed PFOS as the major product.

Neither PFOS nor PFOA were biotransformed after 18 days of incubation. A separate 35-day study of PFOS confirmed this result.

The analytical test results demonstrate that when exposed to municipal wastewater treatment sludge, the tested perfluorooctanesulfonyl-based chemicals degrade through a series of oxidation and dealkylation reactions to PFOS and PFOA. The proposed biodegradation pathway is as follows:

N-EtFOSE-OH $\rightarrow$ N-EtFOSE aldehyde¹ $\rightarrow$ N-EtFOSAA $\rightarrow$ N-EtFOSA $\rightarrow$ N-EtFOSA alcohol² $\rightarrow$ N-EtFOSA aldehyde³ $\rightarrow$ M556 $\rightarrow$ FOSA $\rightarrow$ PFOSulfinate $\rightarrow$ PFOA (abiotic pathway) or PFOSulfinate $\rightarrow$ PFOS (biotic pathway)

Under conditions studied PFOS and PFOA were identified as likely endpoints in the biodegradation of EtFOSE alcohol based chemistries.

Robust summaries and reports from studies of pertinent chemicals are attached.

¹Proposed intermediate, C₈F₁₇SO₂N(C₂H₅)(CH₂COH)

²Proposed intermediate, C₈F₁₇SO₂NH(CH₂CH₂OH)

³Proposed intermediate, C₈F₁₇SO₂NH(CH₂COH)

Table 1

Compound Name	Acronym	Chemical Formula	Laboratory Report Number
2-(N-ethylperfluorooctanesulfonamido) ethyl alcohol	N-EtFOSE-OH	$C_8F_{17}SO_2N(C_2H_5)(CH_2CH_2OH)$	E00-2252, E01-0415
2-(N-Ethyl Perfluorooctane sulfonamido) acetic acid	N-EtFOSAA	$C_8F_{17}SO_2N(C_2H_5)(CH_2COOH)$	E01-0415
N-Ethyl Perfluorooctane sulfonamide	N-EtFOSA	$C_8F_{17}SO_2NH(C_2H_5)$	E01-0415
2-(Perfluorooctane sulfonamido) acetic acid	M556	$C_8F_{17}SO_2NH(CH_2COOH)$	E01-0415
Perfluorooctane sulfonamide	FOSA	$C_8F_{17}SO_2NH_2$	E01-0415
Perfluorooctane sulfinate	PFOSulfinate	$C_8F_{17}SO_2^-$	E01-0415
Perfluorooctanoate	PFOA	$C_7F_{15}COO^-$	E01-0415
Perfluorooctanesulfonate	PFOS	$C_8F_{17}SO_3^-$	E01-0415, E00-2252