

BIOACCUMULATION

TEST SUBSTANCE

Identity: N-Ethylperfluorooctanesulfonamide; may also be referred to as U1464, EtFOSA, EtPOSA, F-6309, or FX-12. (1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptafluoro-N-ethyl-, CAS # 4151-50-2)

Remarks: Material is a white solid of uncharacterized purity.

METHOD

Method/guideline followed: None given for sampling of the organisms. Extraction and analysis procedures were devised by 3M.

Type: Environmental sampling of indigenous fish around a 3M fluorochemical manufacturing facility.

GLP (Y/N): No

Year: 1979

Remarks field: There is no information on sampling procedures of the organisms from the Tennessee River near the manufacturing facility.

Four fish were caught and utilized as samples; Two channel catfish caught above Wheeler Dam, one white bass caught below and one white crappie caught above Wheeler Dam. Wheeler Dam is approximately 26 nautical miles downstream from the 3M Decatur Plant effluent discharge. It was not noted in the report how many miles above and below the dam the fish were caught.

A ten ppm standard of FM-3422 (N-EtFOSE alcohol) was prepared by diluting 1 ml of a 100 ppm standard (in ethyl acetate) to mark with ethyl acetate in a 10 ml volumetric flask.

One whole channel catfish was homogenized to create one sample. The other channel catfish was dissected and the various individual parts were homogenized to create individual samples.

The white bass had a 6.3 cm i.d. dinker die core sample taken just off the lateral line behind the gill plate making up a 20.591 g sample containing skin, filet, small part of the backbone, reproductive organs, part of the kidney, and rectum.

The white crappie had a dinker die core sample taken behind the gill plate to create a 16.684 gram sample containing filet, vertebrae, skin and bile.

All samples were homogenized in known volumes of DI water and divided into five aliquots each.

Samples were centrifuged, extracted with ethyl acetate, and analyzed by GC for organic and inorganic fluoride.

RESULTS

EtFOSA Concentration
In Tennessee River Fish by GC

Sample	EtFOSA (ppm)
Water blank	N.D.
Ethyl Acetate blank	N.D.
Whole Channel Catfish	0.40
White Bass core sample	0.82
White Crappie core sample	0.06
Channel Catfish Gills	1.48
Channel Catfish Liver	2.17
Channel Catfish Parts*	1.33
Channel Catfish Muscle	N.D.
Channel Catfish Fat **	13.85
Channel Catfish Gall Bladder	1.57

* Consisted of muscle, skin, blood, bone, and cartilage.

** Consisted of gastrointestinal tract, reproductive system, and fat.

Upon completion of GC analysis, there was concern that the values were not definitive. Additional analysis was then done using Capillary Gas Chromatography with Electron Capture and a Microwave Sustained Helium Plasma Detector. Results from only the white bass core sample and the catfish gill sample were described in this report.

Qualitative analysis of the fish extracts using Capillary Gas Chromatography with electron capture failed to quantitate EtFOSA. However, the white bass core sample showed a peak with a retention time similar to EtFOSA. This peak area was less than the EtFOSA standard, but greater than that seen in the channel catfish gills, which was described as a "very small amount". Analysis by a Microwave Sustained Helium Plasma Detector found no fluorocarbon peaks. The results obtained by the microwave plasma detector on spiked samples indicated that N-EtFOSA, if present, could have been detected from its fluorine content at 0.1 ppm in the ethyl acetate extracts.

Remarks: The original report (5/22/79) referenced a sample for FM-3923. It was brought up after the report was generated that FM-3923 and FM-3422 are both the same compound (N-EtFOSE alcohol). Analytical was conducted to verify its identity and it was found to be N-EtFOSA (F-6309). The attached report ("AR No. 7238 - Determination of Fluorinated

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Alcohols in Fish Extracts", 10/23/79) still refers to FM-3923 when in fact the sample labeled as FM-3923 is F-6309. This report also has inconsistencies. The last paragraph indicates the ability to detect fluorine content at 0.1 ppm level. However, a review of the procedure used indicates a detection limit of 0.5 ppm.

The first report (5/22/79) describes analysis of ethyl acetate extracts of fish homogenate by gas chromatography (GC) with electron capture detection. The analysis shows the presence of materials in fish tissue extracts that have GC retention times identical to both N-MeFOSE alcohol and N-EtFOSE alcohol and to N-EtFOSA. The GC retention times of N-MeFOSE alcohol and N-EtFOSE alcohol standards were the same (not resolved) by the method used in the first report. The first report indicates the presence of fluorochemicals in the fish extracts, but electron capture detection is not specific for fluorochemicals. Thus the results reported in the first report were not a specific identification of fluorochemicals detectable by GC. (Report 1 also has errors in column 4 of Table 1. In the 1B row, 0.40 should be changed to 4.13, and in the 2A row, 0.004 should be changed to 0.06.)

The second report (12/28/79) shows a misinterpretation in the first report. It includes a description of GC analyses of ethyl acetate extracts of two of the samples described in report 1 samples 1B and 3A. The work described in report 2 used electron capture detection and references a report using microwave sustained helium plasma detection (MSHPD) in the fluorine and sulfur mode. In fluorine mode, MSHPD method is specific for fluorine. The MSHPD results show no fluorochemicals in the ethyl acetate extracts. The results are interpreted as indicating that F-6309 and N-EtFOSE alcohol (FM-3422) are present in the ethyl acetate extracts at less than 0.1 ppm. In the first report, N-EtFOSA (F-6309) and N-MeFOSE alcohol (FM-3925) / N-EtFOSE alcohol (FM-3422) had appeared to be present respectively at 0.82 and 3.31 ppm in sample 1B and at 1.48 and 0.80 ppm in sample 3A. Thus, the GC-able compounds seen in the first report appear not to have been fluorochemicals and thus could not have been N-MeFOSE alcohol, N-EtFOSE alcohol or N-EtFOSA.

The first report shows the presence of unidentified organic fluorine and of inorganic fluorine in the fish tissue. This was not re-evaluated in the second report.

CONCLUSIONS

No reliable conclusions can be derived from this study.

Submitter: 3M Company, Environmental Laboratory, P.O. Box 33331,
St. Paul, Minnesota, 55133

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DATA QUALITY

Reliability: Klimisch ranking 3. Without an understanding of the sampling design in relation to the outfall and sampling points, verifiable data on the actual concentrations of fluorochemicals in the river from both the manufacturing facility and from natural sources, activities in the manufacturing facility prior to sampling, any applicable environmental conditions (e.g. rain events), and a clear understanding of how long the sampled fish were in the sampling area, there is little to be concluded. Additionally, the analytical data conflicts. It cannot be definitively concluded which analytical data set is correct.

REFERENCES

3M Technical Report "Bioaccumulation of Fluorochemicals in Tenn. River Fish." James E. Gagnon, Project 78-2740, Decatur, Alabama – Tennessee River Fish, Report Number 001, May 22, 1979

3M Technical Report "Fluorochemicals in Tennessee River Fish." James E. Gagnon, Project 78-2740, Decatur, Alabama – Tennessee River Fish, Report Number 100, December 28, 1979

3M requested expert overview, "Bioaccumulation Studies", Dr. James Gillett, Cornell University, March 8, 1993

OTHER

Last changed: 5/18/00

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6. *Report No. 001 (5/22/79) "Bioaccumulation of Fluorochemicals in Tenn. River Fish" and Report No. 100 (12/28/79) "Fluorochemicals in Tennessee River Fish."*

This pair of papers is quite confusing, largely because of incorrect standards, confused identity of labels and verity of contents, and the difficulty of actual determinations. When these are combined with a lack of clear sampling design in relation to outfall and sampling points, the result add little to our understanding of the problem. These papers make an excellent example of how a little knowledge can be dangerous.

3M

Form 6747-11-A

TECHNICAL REPORT SUMMARYDate
5/22/79

TO: TECHNICAL COMMUNICATIONS CENTER - 201-2CN

(Important - If report is printed on both sides of paper, send two copies to TCC.)

DEC 20 1979

Division	Environmental Laboratory (EE & PC)	Dept. Number	0222
Project	Decatur, Alabama - Tennessee River Fish	Project Number	78-2740
Report Title	Bioaccumulation of Fluorochemicals in Tenn. River Fish	Report Number	001
To	D. L. Bacon		
Author(s)	James E. Gagnon	Employee Number(s)	213531
Research Reference	51568 Lab Request #4871	No. of Pages Including Cover Sheet	10 ⁽²⁾
SECURITY ▶	<input checked="" type="checkbox"/> Open (Company Confidential)	<input checked="" type="checkbox"/> Closed (Special Authorization)	3M CHEMICAL REGISTRY ▶
		New Chemicals Reported	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No

KEYWORDS:
(Select terms from 3M
Thesaurus. Suggest other
applicable terms.)EE & PC
Decatur

CURRENT OBJECTIVE: Qualitative and quantitative determination of F 6309, FM-3925, and FM-3422 in fish taken from the Tennessee River above and below Wheeler Dam at 3M's Decatur plant. Analyze for organic and inorganic fluoride in the same samples.

REPORT ABSTRACT: (200-250 words) This abstract information is distributed by the Technical Communications Center to alert 3Mers to Company R&D. It is Company confidential material.

Ethyl acetate extracts of a Channel catfish (*Ictalurus punctatus*), ~~white perch (*Morone chrysops*)~~ and ~~bluegill (*Lepomis macrochirus*)~~ (*annularis*) were analyzed by gas chromatography.**BEST COPY AVAILABLE**cc: D. Ricker-236-28
A. Welter
A. MendelInformation Liaison
10/11/79

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BEST COPY AVAILABLEINTRODUCTION

It is known that 3M's Decatur, Alabama plant effluent has high organic fluoride levels, 10.9 ppm (1)(2). It has also been shown that fluorochemicals can bioaccumulate in fish in a laboratory environment (3)(4). With these combined factors, the next step was to see if fish caught in the Tennessee River near the Decatur plant had detectable levels of fluorochemicals.

RESULTS AND DISCUSSION

Table 1 lists the concentration, in ppm, in fish of compounds which have the same retention time as the three fluorochemicals of interest (F-6309, FM-3925, and FM-3422).

Analysis of the results for the dissected channel catfish, Sample 3A, shows that the fluorochemicals bioconcentrate to a greater extent in the gastrointestinal tract, reproductive system, and fat. It can also be seen that the muscle layer was found not to bioaccumulate the three fluorochemicals of interest. These results agree with earlier reports (3)(4).

When comparing the total fluorochemical content (TFC) for the two whole fish samples, the larger channel catfish contained more than twice the fluorochemical content, 2.74 ppm vs. 1.13 ppm. Since both fish were caught in the same area, a reasonable explanation for this may be related to the high partition coefficients for channel catfish. Fluorochemicals bioaccumulate in fatty tissue, and since more fatty tissue is present in the larger fish, more fluorochemicals would be expected.

F-6309 is present at higher concentrations in the dissected channel catfish, sample 3A, than other samples. Since bioaccumulation rates have not been determined for F-6309 no explanations for the higher concentrations can be offered.

The two fish samples which had cores taken from them will not be rigorously compared to whole fish samples. The reason for this is that the core samples may not have representative concentrations of fluorochemicals (whole fish values may be higher or lower). Since core samples were taken from the approximate same location, the results can be rigorously compared.

The white bass from below Wheeler Dam, sample 1B, had a whole fish TFC of 0.40 ppm, while the white crappie from above Wheeler Dam, sample 2A, had a whole fish TFC of 0.004 ppm. With such small statistical samples, it would be difficult to say that the larger TFC is due only to the white bass living in the presence of higher fluorochemical concentration, downstream from the plant. Other possible explanations for the higher TFC could be the following:

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TABLE 1

**FLUORO-CHEMICAL CONCENTRATION (ppm)
IN TENNESSEE RIVER FISH**

<u>Sample</u>	<u>F-6109</u>	<u>FM-3925 & FM-3422 (1)</u>	<u>Total Combined FC in Fish (ppm) (2)</u>
1A - Whole fish	0.40	0.73	1.13
1B - Core (3)	0.82	3.31	0.40 (4)
2A - Core (5)	0.06	N.D. (6)	0.004 (4)
3A - Gills	1.48	0.80	
3A - Liver	2.17	0.38	
3A - Parts (7)	1.33	0.43	2.74 (9)
3A - Muscle	N.D.	N.D.	
3A - Fat (8)	13.85	6.12	
3A - Gall bladder	1.57	0.74	
Water blank	N.D.	N.D.	
Ethyl acetate blank	N.D.	N.D.	

Footnotes to Table 1:

- (1) FM-3925 and FM-3422 cannot be resolved with GC parameters used; therefore, a combined value is reported.
- (2) Based on frozen weight of the fish.
- (3) Sample core, 3.61 cm, id contained skin, filet, reproductive organs, and parts of kidney, rectum, and backbone.
- (4) Assumes that the concentrations obtained in the core are representative of the rest of the fish.
- (5) Sample core, 3.61 cm id contained filet, vertebrae, skin, and bile.
- (6) N.D. = Not detected.
- (7) Consisted of muscle, skin, blood, bone, and cartilage.
- (8) Consisted of gastrointestinal tract, reproductive system, and fat.
- (9) Based on the actual weight of sample used, 18.8% less than frozen weight, and weight percent of each part.

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1. Longer river residence time, older fish.
2. Longer location residence time.
3. Different species
 - a) Different feeding and life styles
 - b) Contains larger weight percent of organs which tend to bioaccumulate fluorochemicals
 - c) Larger fluorochemical partition coefficients

If the core samples are representative of whole fish concentrations, then it can be postulated that channel catfish bioaccumulate fluorochemicals to a greater extent than either white bass or crappie. Reasons for this are the same as listed above.

Table 2 gives the results of the organic (RF) and inorganic fluoride (F^o) concentration, in ppm, in the fish samples.

TABLE 2 (5)
ORGANIC (RF) AND INORGANIC (F^o)
FLUORIDE CONCENTRATIONS (ppm)

<u>Sample</u>	<u>RF</u>	<u>F^o</u>
1A	9.7	24.6
2A	16.2	13.3
1B	10.5	6.2
Water	N.I.	0.01

Jon Bolisic points out that the high inorganic fluoride values seem rather surprising. His only explanation was that fish flour previously analyzed, for a different requestor, was shown to have inorganic fluoride values higher than organic fluoride. Jon also states that high inorganic fluoride values would make it difficult to calculate low levels of organic fluoride.

Comparison of the organic and inorganic fluoride content shows that samples from above Wheeler Dam have just as high, if not higher, values than for the sample from below the dam. There are no clear cut explanations for this observation. An earlier analysis of Tennessee River water showed high organic fluoride concentrations upstream from the plant. At that time, it was thought the samples may have been mislabeled. With these results,

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it would seem to indicate that the concentration of fluorochemicals may actually be less below Wheeler Dam. This may be caused by volatilization of the fluorochemical when going over the dam (1), settling of fluorochemicals before the dam.

Comparison of organic fluoride values from Tables 1 and 2 show no correlation. For example, the highest organic fluoride value, 16.2 ppm for sample 2A, had the lowest TYC, 0.004 ppm, for the fluorochemicals analyzed. A possible explanation is that there are organic fluorides present in very high concentrations which were not analyzed for individually. The species which had the highest fat content, channel catfish, had the lowest organic fluoride concentrations.

With limited sample population (2 fish of one species and one of each of two other species), it is difficult to draw any meaningful conclusions. The only definite conclusion is that the fluorochemicals studied do appear to bioaccumulate in river fish under natural conditions.

EXPERIMENTAL

1. Sample materials

Fish

- 1A - Small channel catfish (*Ictalurus punctatus*), caught above Wheeler Dam in Tennessee River.
- 1B - White bass (*Ameiurus chrysops*), caught below Wheeler Dam in Tennessee River.
- 2A - White crappie (*Pomoxis annularis*), caught above Wheeler Dam in Tennessee River.
- 3A - Large channel catfish (*Ictalurus punctatus*), caught above Wheeler Dam in Tennessee River.

Standards

F-6309, FM-3925, and FM-3422.

Ten ppm standards of F-6309, FM-3925, and FM-3422 were prepared by diluting 1 ml of a 100 ppm standard, in ethyl acetate, to mark with ethyl acetate in separate 10 ml volumetric flasks.

2. Analysis Instruments/Materials

Blender:

Waring Commercial blender, Model #91-263, available from Waring Products Division, Route 44, New Hartford, CT 06057.

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Tissuemizer:

Model #SDT, available from Tekmar Company, P. O. Box 37202, Cincinnati, OH 45222.

Dinker Die:

3.61 cm id AISI-02 high carbon steel cutting die made by Jerry Guthrie in Central Research Labs, described in 3M Technical Notebook #51568-35.

Mixer:

"Vortex Genie" Model #K-550-G, available from Scientific Industries, Inc., Bohemia, NY 11716.

Centrifuge:

Damon-IEC Model #B-20A, available from Damon-IEC Corporation, Needham Heights, MA.

Bottles:

Four-ounce widemouthed clear glass bottle sealed with aluminum foil and aluminum foil-lined caps.

125-ml linear polyethylene (LPE) plastic bottle with polyseal caps.

Gas Chromatograph:

Chromatograph - Hewlett-Packard Model 5713 GC.
Integrator - Hewlett-Packard Model 3380A integrator-printer.

Both of the above available from Hewlett-Packard Co., 150 Page Mill Road, Palo Alto, CA 94304.

Column - Six-foot, 1/8 inch OD, stainless steel, packed with 10% CW20M on 60/80 Chromasorb W-AW.

Column Temperature - Isothermal 180° C.

Injector - On-column at 200° C.

Detector - Electron Capture at 300° C.

Flow - ~40 cc/minute of Argon:Methane (95/5).

Ethyl Acetate:

"Li Chromolv" chromatography solvent available from MC/B Manufacturing Chemists, 2909 Highland Avenue, Norwood, OH 45212, see Catalog #6008688M.

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- and fat.
- (9) Based on the actual weight of sample used, 18.8% less than frozen weight, and weight percent of each part.

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Water:

Deionized water.

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3. Procedure (6)

Procedures used below, except for minor modifications, were obtained from earlier 3M Technical Report summaries (7).

Samples 1A through 3A and 1B were removed from the freezer and placed in large aluminum pans, in a fume hood, and allowed to thaw.

A whole channel catfish, sample 1A, was cut into 5 sections and homogenized in a blender with 200 ml water.

Sample 1B had a dinker die core sample taken just off the lateral line behind the gill plate. Contents of the 20.591 gram sample were skin, filet, small part of backbone, reproductive organs, part of kidney, and rectum.

Sample 2A had a dinker die core sample taken behind the gill plate. The 16.684 gram sample contained filet, vertebrae, skin, and bile. Samples 1B and 2A were homogenized with 10 ml of water in a "tissuemizer."

Sample 3A was dissected, and the various individual parts were homogenized with water. Individual parts weighing more than 25.0 grams were homogenized in a blender, while those of lesser weight were homogenized in a "tissuemizer." Table 3 lists the sample, sample weight, and amount of water added for homogenizing each sample.

All of the above samples, after homogenization, were divided into five aliquots and placed in precleansed bottles, (dichromate/acid, water rinse, dry, toluene, dry). Three aliquots were placed in LFK bottles, while the other two were placed in glass bottles. Samples were stored in a refrigerator at 4.5° C. until needed.

Samples analyzed for F-6309, FM-3925, and FM-3422 were prepared according to the following procedure. See Table 4 for weight of sample and milliliters of ethyl acetate used for extractions.

A previously homogenized sample, stored in a glass bottle, was weighed (no larger than 4.00 g) and added to a 30-ml precleansed glass centrifuge tube. A volume of ethyl acetate was added at the rate of 1.0 ml ethyl acetate per gram of homogenate. The ethyl acetate/fish homogenate were mixed for 1.5 minutes in a mixer at a speed setting of 3. The samples were removed and centrifuged at 1500 rpm at

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21° C. for 10 minutes. After centrifuging, the ethyl acetate layer was separated, by use of a pipet, and placed in a vial. Five µl of sample (standard) was injected for gas chromatographic analysis.

Samples 1A, 2A, and 1B homogenates, plus a water blank, in LPE bottles, were sent to Jon Belisle of the Central Research Laboratory for organic and inorganic fluoride analysis.

REFERENCES

- (1) 3M Technical Report Summary, August 30, 1978, Arthur Mendel to R. L. Bohon, "Fate of Fluorochemicals Project - Progress Report."
- (2) Central Research Laboratory Report Number 6902, April 20, 1978, Jon Belisle.
- (3) "Bioconcentration of FM-3422 in Bluegill Sunfish and in Channel Catfish," M. T. Elzabarawy to A. N. Welter, May 17, 1977.
- (4) 3M TRS, August 16, 1978, A. N. Welter to D. L. Bacon, "Evaluation of the Bioconcentration Potential of FM-3422."
- (5) Central Research Laboratory Report on Request #A72199 by Jon Belisle, May 7, 1979.
- (6) Experimental work done in cooperation with A. N. Welter of the Environmental Laboratory (EE & PC), who performed the dissections and homogenizations.
- (7) 3M Technical Report Summary, November 15, 1977, A. Mendel to D. L. Bacon, "Analytical Methodology on FM-3422."

John E. Segura
JEG/ces

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