Comparison of Measured Aquatic Toxicity Data with EPA, OPPT SAR Predictions

PPG Industries, Inc. and U.S. EPA, OPPT
Study conducted in 1999 and 2000
Results presented by Dr. Chun as a poster at the March 2001 meeting of the Society of Toxicology (SOT) and at the November 2002 Society of Environmental Toxicology and Chemistry (SETAC) meeting in Salt Lake City, UT.

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SUMMARY

PPG Industries, Inc. and U.S. EPA, OPPT compared measured acute aquatic toxicity data with Structure Activity Relationship (SAR) predictions for 38 compounds that had already been commercialized at PPG. Results showed 91% agreement (defined as ± 1 order of magnitude, or SAR data predicted that the compound caused no effects at saturation and the experimental data showed no effects at the maximum attainable or limit test values). Results of this comparison were presented by Jean Chun, PPG Industries, as posters at the March 2001 meeting of the Society of Toxicology (SOT) in San Francisco, CA and at the November 2002 Society of Environmental Toxicology and Chemistry (SETAC) meeting in Salt Lake City, UT. Actual data and chemical identity are PPG Confidential Business Information and can not be released.

ABSTRACT

Experimental aquatic toxicity data on several different types of polymers were compared with the data generated by structure activity relationship (SAR) predictions using EPA, OPPT's Pollution Prevention (P2) Framework http://www.epa.gov/oppt/p2framework/. The P2 Framework models (see Appendix) provide screening-level information by estimating physical-chemical properties, fate in the environment, toxicity to aquatic organisms, and carcinogenicity. Additional models in the P2 Framework predict occupational, consumer, and general population exposure to humans. These models were developed to screen new chemicals, which often lack measured data, under the Toxic Substances Control Act. This validation study was conducted in 1999 to evaluate the U.S. EPA SAR methods used to predict aquatic toxicity of polymers. The experimental data were obtained from an algae growth inhibition test, a *Daphnia* acute immobilisation test, or an acute toxicity test to Rainbow trout (*Oncorhychus mykiss*). The studies were conducted by four different contract laboratories located in the United States or in the United Kingdom following OECD guidelines and Good Laboratory Practice standards.

Measured data from the laboratory studies on a total of 38 polymers, listed below, were compared against SAR predictions. There were a total of 55 actual data points from the laboratory tests, and not all endpoints were addressed for each of the 38 polymers. Data were considered to be in agreement if the SAR predictions were within the same order of magnitude (less than a ten-fold difference) as the experimental data. Data were also considered to be in agreement if the SAR prediction indicated that the material caused no effects at saturation (NES) or a low concern for toxicity and the experimental data showed no effects at the maximum attainable concentration or an EC50/LC50 value of >100 mg/L. Forty-eight out of the 55 SAR predictions were in agreement when compared to the experimental data. Five SAR predictions were not in agreement with the experimental data. Two SAR predictions were considered as inconclusive. Overall, the reliability of SAR predictions as compared to the experimental data was 87 to 91 percent depending on whether or not the two inconclusive results are included.

PROCEDURES

Materials Evaluated

Polyesters	7	Acrylates	8
Epoxy materials	13	Miscellaneous Materials	5
Polyurethane	5	Total	38

Data Evaluated

Predictions were produced using Structure Activity Relationships (SARs) developed by EPA OPPT and used to screen new chemicals in the absence of data.
Experimental Data were obtained from the following three types of laboratory tests (not all types of tests were conducted on each of the materials evaluated):

- Acute Toxicity to Rainbow Trout
- Daphnia Immobilization
- Algae Growth Inhibition

The studies were conducted in four different contract laboratories in the USA or in the UK following OECD guidelines and Good Laboratory Practice standards.

DATA COMPARISON

Tables showing the data comparisons are included at the end of this report. Data in the tables that are considered to be not in agreement are underlined. Data were considered to be in agreement if one of the following are true:

- SAR Predictions were within the same order of magnitude (less than ten-fold difference).
- The SAR data predicted No effects at Saturation (NES) and the experimental data showed No effects at the maximum attainable or limit test values.
- EPA predicted a low concern and the experimental data showed No effects at the maximum attainable or limit test values.

CONCLUSIONS

When compared to the 55 laboratory test results, 48 SAR predictions were considered reliable. Five SAR predictions were not in good agreement with the experimental data. Comparison of two SAR predictions with corresponding data was considered inconclusive. Overall, the reliability of SAR predictions as compared to the experimental data was 91% excluding two inconclusive results.

These results lead to the following conclusions:

- SAR models provided a reliable method for predicting aquatic toxicity of the groups of polymers evaluated.
- These models will provide adequate information for a screening level hazard evaluation of PPG Polymers.
- An additional advantage of using these models is that the EPA / OPPT's SAR analysis evaluates multiple potential aquatic effects and concerns of a material while experimental data usually only addresses one or two species of concern.

Reliability of SARs When Compared to Experimental Data

Groups and Numbers of Polymer Substances Tested	*Daphnia* Data	Fish Data	Algae Data	Overall Reliability
Polyester (7)	1 / 1 *	3 / 3	4 / 4	100%
Polyurethane (5)	3 / 3	1 / 1	2 / 2	100%
Acrylates (8)	4 / 6 (4 / 4) **	2 / 2	4 / 5	77% (91%) **
Epoxides (13)	13 / 13	5 / 5	0 / 3	86%
Anhydrides (4)	2 / 2	2 / 2	2 / 2	100%
Melamine (1)	0 / 1			0%
Total (38)	23 / 26 (23 / 24) **	13 / 13	12 / 16	87% (91%) **

* Numbers in Agreement / Numbers Evaluated.
** Two comparisons were considered to be inconclusive.
Values in ( ) are excluding inconclusive results.

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Comparison of SARs and Experimental Data: Polyester Group

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 1 Polyester	>80	NES		NES	>100	>5.8
Material 2 Polyester with glycol		Low Concern	>100 Nominal	Low Concern		
Material 3 Polyester polyol		>100	>36	>100		>100
Material 4 Polyester with glycol		Low Concern	>100 Nominal	Low Concern		
Material 5 Polyester polyol		NES		NES	NES	NES
Material 6 Polyester		>100		>100	>9 Nominal	>100
Material 7 Aliphatic polyester					>10 Nominal	Low Concern

Comparison of SARs and Experimental Data: Polyurethane Group

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 8 Polyol, diisocyanate, ether	>3.8 Highest Attainable	NES	>2.4 Highest Attainable	NES		NES
Material 9 Polyurethane	277 Nominal	170				
Material 10 Water reducible – Urethane	>100 Nominal	Low Concern				
Material 11 Urethane		NES		NES	>0.3 Highest Attainable	NES
Material 12 Polyurethane					270 Nominal	Low Concern

Comparison of SARs and Experimental Data: Acrylate Group

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 13 Styrenated methacrylate	>2.8 Highest Attainable	Low Concern			Low Toxicity	Low Concern
Material 14 Styrenated methacrylate	>100 Nominal	NES		NES	>100 Nominal	Low Concern
Material 15 Styrenated methacrylate		Low Concern	>1000 Nominal	Low Concern	110 Nominal **	Low Concern
Material 16 Styrenated acrylic	447 Nominal	Low Concern				
Material 17 Acrylic resin solution	255 Nominal	Low Concern				
Material 18 Cationic acrylic	>10 Nominal	34	2.1	5.0	0.23 Nominal	3.2
Material 19 Acrylic methacrylic	>100 Nominal (insoluble) **	15		3.6		
Material 20 Acrylic resin					>0.5 Highest Attainable	Low Concern

Underline = Not in agreement
Asterisks = Inconclusive

Comparison of SARs and Experimental Data: Water-based Modified Epoxy Group

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 21 Epoxy amine	0.32	0.47	4.2	0.83		
Material 22 Epoxy amine	14	48		5.8		
Material 23 Amine functional urethane / ether / ester	7.8 Nominal	52		6.0		
Material 24 Ether polyamine	4.0 Nominal	34	1.3 Nominal	5.0		
Material 25 Modified epoxy	0.15	1.23	4.2	1.4		
Material 26 Substitute epoxy	56	8.5	1.7	3.0		
Material 27 Functional aromatic polyether	62	8.5	20	3.0		

Comparison of SARs and Experimental Data: Other Epoxy Group

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 28 Phosphate metallic epoxy	>200 Nominal	Low Concern		Low Concern		
Material 29 Neutralized polymer	>4.0 Nominal	Low Concern		Low Concern		
Material 30 Carbonmonocyclic alkylene phosphate	160 Nominal	Low Concern		Low Concern	21 Nominal	Low Concern
Material 31 Epoxy amine, solvent based	>100 Nominal (insoluble)	>0.27		>0.27		
Material 32 Epoxy modified chlorinated hydrocarbon	>100 Nominal	NES		NES	79 Nominal	NES
Material 33 Epoxy modified chlorinated hydrocarbon	>100 Nominal	Low Concern		Low Concern	53 Nominal	Low Concern

Underline = Not in agreement

Comparison of SARs and Experimental Data: Reactants, Melamine, Acid & Anhydride

Material Name	*Daphnia* Exp. Data EC50 (mg a.i./L)	*Daphnia* SAR Data EC50 (mg a.i./L)	Fish Exp. Data EC50 (mg a.i./L)	Fish SAR Data EC50 (mg a.i./L)	Algae Exp. Data EC50 (mg a.i./L)	Algae SAR Data EC50 (mg a.i./L)
Material 34 Aliphatic polyanhydride	>100 Nominal	NES		NES	>100 Nominal	Low Concern
Material 35 Crosslinker urethane acid functional		NES	>100 Nominal	NES		NES
Material 36 Amine phenol-formaldehyde	2.45 Nominal	0.1		0.28		
Material 37 Melamine formaldehyde	>110	NES	>110	NES		
Material 38 Urethane polyanhydride					>100 Nominal	NES

Underline = Not in agreement

Appendix

P2 FRAMEWORK MODELS

Models to Estimate Physical / Chemical Properties		
Model	**Output**	**Input**
MPBPVP	Melting and Boiling Points, Vapor Pressure	CAS No. or Chem. Str. In SMILES
KOWWIN	Octanol / water partition coefficient	CAS No. or Chem. Str. In SMILES
WSKOWWIN	Water solubility from log KOW	CAS No. or Chem. Str. In SMILES
HENRYWIN	Henry's law constant: VP / WS	CAS No. or Chem. Str. In SMILES
Models to Estimate Chemical Fate in the Environment		
Model	**Output**	**Input**
AOPWIN	Atmospheric oxidation potential	CAS No. or Chem. Str. In SMILE
BCFWIN	Bioconcentration factor	CAS No. or Chem. Str. In SMILES
BIOWIN	Biodegradation rate	CAS No. or Chem. Str. In SMILES
HYDROWIN	Hydrolysis rate	CAS No. or Chem. Str. In SMILES
PCKOCWIN	Soil organic carbon partition coefficient	CAS No. or Chem. Str. In SMILES
STPWIN	Percent removal in POTW	CAS No. or Chem. Str. In SMILES
Models to Estimate Hazards to Humans and the Environment		
Model	**Output**	**Input**
OncoLogic	Cancer hazard potential	Chemical structure
ECOSAR	Acute and Chronic toxicity to fish, invertebrates, algae	CAS No. or Chem. Str. In SMILES
Models to Estimate Exposure and / or Risk		
Model	**Output**	**Input**
E-FAST	Surface water ingestion, fish ingestion, ground water ingestion, ambient air inhalation, indoor air inhalation, dermal exposure, aquatic environment exposure / risk	Physical / chemical properties, fate properties, release amounts, release medium, release location, aquatic concentration of concern, NPDES number
ReachScan	Impact of surface water discharges on drinking water facilities, chemical concentration downstream at drinking water intake point	Facility location (NPDES number), release data
Occupational Exposure Spreadsheets	Vapor generation rates and worker exposure to vapors during filling, sampling, and to open liquid pools and during degreasing operations; water releases and worker exposures to powders during textile dyeing	Molecular weight, vapor pressure, operation hrs/day, worker exposure hrs/day; if applicable volume of degreasing solvent or dye used, dye exhaust rate