



A program supported by the NIH

Assessment of exposure to chemicals of uncertain body burden and multi-panel chemical assay for analysis in ECHO

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Exposure Assessment



dose = f (concentration in blood)
concentration in blood = f (dose)

Phthalate Exposure Dose Urinary Concentration \rightarrow Exposure Dose

 $DI = CV \times \frac{M_1}{M_2} \times \frac{1}{f}$

DI is the total daily intake of phthalates (µg/day)

C is the urinary phthalate metabolite concentration (µg/L)

V is human daily excretion volume of urine (L/day)



2010 - Median total phthalate conc in urine: 240 ug/L Median exposure dose in the US population: ~550 ug/d

Sources of phthalate exposure

A Survey of Phthalates and Parabens in Personal Care Products from the United States and Its Implications for Human Exposure

Ying Guo and Kurunthachalam Kannan* | Environ. Sci. Technol. 2013, 47, 14442-14449

Perfumes, deodorants, nail polish - 10s - 1000s of µg/g Adult female exposure: 22 µg/day



DEP

DEHP

BP

Comparative Assessment of Human Exposure to Phthalate Esters from House Dust in China and the United States

Ying Guo[†] and Kurunthachalam Kannan^{†,†,*} Environ. Sci. Technol. 2011, 45, 3788–3794

Concentrations in indoor air: 100s – 5000s ng/m³ Concentrations in indoor dust: 10s - 100s of µg/g Adult female exposure: 16 µg/day



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Phthalate Concentrations and Dietary Exposure from Food Purchased in New York State

Arnold Schecter,¹ Matthew Lorber,² Ying Guo,³ Qian Wu,^{3,4} Se Hun Yun,^{3,4} Kurunthachalam Kannan,^{3,4} Madeline Hommel,¹ Nadia Imran,¹ Linda S. Hynan,⁵ Dunlei Cheng,¹ Justin A. Colacino,⁶ and Linda S. Birnbaum^{7,8}

Concentrations in food: few – 100 ng/g Adult female exposure: 60 µg/day

Unknown sources of phthalate exposure



Only one-fifth of the exposure sources is accounted for



Microplastics exposure dose: up to 10 mg/d

Many unknown phthalate metabolites in urine – not measured



Secondary metabolites and adducts

Many unknown phthalate metabolites exist in urine

Biomarkers to elucidate adverse outcome pathways in human diseases

ORIGINAL ARTICLES: ENVIRONMENT AND EPIDEMIOLOGY

Urinary bisphenol A, phthalates, and couple fecundity: the Longitudinal Investigation of Fertility and the Environment (LIFE) Study

Buck Louis et al. Fertility and Sterility (2014), 101, 1359

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HHEAR Laboratory and Data Analysis Services

Researchers who want to add or expand exposure analysis to their studies of human health



Expert consultation on exposure analysis, study design, and methods

Statistical analysis, data integration and interpretation

A data repository and associated data science tools



Targeted (hypothesis driven) analysis of biological samples

Untargeted (discovery driven) analysis of biological samples

Targeted and untargeted analysis of environmental samples



https://hhearprogram.org/

~350 chemicals biomonitored in the U.S.

>40,000 chemicals used in the U.S. (~8,000 high production volume)

>9.5 Trillion pounds of chemicals per year in the U.S. (~30,000 lbs/person) USEPA's TSCA has an inventory of >86,000 chemicals

 Key Gap
 Only a fraction of chemicals have been measured in pregnant women or children

ECHO'S CHEMICAL EXPOSURE WORKING GROUP

Goals:

- Develop **recommendations** for chemical exposures to be measured in ECHO cohorts
- Support **science** evaluating chemical exposures and child health effects



Identifying and prioritizing candidate chemicals

Review

A Section 508-conformant HTML version of this article is available at https://doi.org/10.1289/EHP5133.

Identifying and Prioritizing Chemicals with Uncertain Burden of Exposure: Opportunities for Biomonitoring and Health-Related Research

Edo D. Pellizzari,¹ Tracey J. Woodruff,² Rebecca R. Boyles,³ Kurunthachalam Kannan,⁴ Paloma I. Beamer,⁵ Jessie P. Buckley,⁶ Aolin Wang,² Yeyi Zhu,^{7,8} and Deborah H. Bennett⁹ (Environmental influences on Child Health Outcomes)

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 ⁷Northern California Division of Research, Kaiser Permanente, Oakland, California, USA
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 ⁹Department of Public Health Sciences, University of California, Davis, Davis, California, USA

We selected 155 chemicals for evaluation based on a rigorous process using extant data. We prioritized chemicals based on:

- Present in consumer products
- Quantifiable in environmental samples
- Potentially toxic
 chemical structure
- Not previously wellcharacterized

BACKGROUND: The National Institutes of Health's Environmental influences on Child Health Outcomes (ECHO) initiative aims to understand the impact of environmental factors on childhood disease. Over 40,000 chemicals are approved for commercial use. The challenge is to prioritize chemicals for biomonitoring that may present health risk concerns.

OBJECTIVES: Our aim was to prioritize chemicals that may elicit child health effects of interest to ECHO but that have not been biomonitored nationwide and to identify gaps needing additional research.

METHODS: We searched databases and the literature for chemicals in environmental media and in consumer products that were potentially toxic. We selected chemicals that were not measured in the National Health and Nutrition Examination Survey. From over 700 chemicals, we chose 155 chemicals and created eight chemical panels. For each chemical, we compiled biomonitoring and toxicity data, U.S. Environmental Protection Agency exposure predictions, and annual production usage. We also applied predictive modeling to estimate toxicity. Using these data, we recommended chemicals either for biomonitoring, to be deferred pending additional data, or as low priority for biomonitoring.

Environmental Health Perspectives, (2019) 127, 126001

Developing chemical assay panel

- 7 chemical panels; ~48 compounds
- Majority of them have urinary biomarkers; PFASs in serum
- Some are GC type and some are LC type chemicals
- To the list add routinely measured flame retardants, plasticizers, phenols and pesticides that have similar properties and can be analyzed in the same method

| Alternative flame retardants | | | | | | |
|---|--|--|--|--|--|--|
| Bis(2-ethylhexyl) tetrabromophthalate (BEH-TEBP) | Melamine | | | | | |
| Hexabromobenzene (HBBz) | Cyanuric acid** | | | | | |
| Hexabromocyclododecane (HBCD) | | | | | | |
| Alternative plasticizers | | | | | | |
| Bis(2-ethylhexyl) adipate (DEHA) | Bis(2-ethylhexyl)-1,4-terephthalate (DEHT) | | | | | |
| Aromatic amines | | | | | | |
| 2-Methoxyaniline (Anisidine) | 2,4-Diaminotoluene*** | | | | | |
| 2-Methylaniline | 4,4'-Diaminodiphenylmethane*** | | | | | |
| 3,4-Dichloroaniline | | | | | | |
| Environmental phenols | | | | | | |
| Bisphenol A diglycidyl ether (BADGE) | 3,3',5,5'-Tetrabromobisphenol A (TBBPA) | | | | | |
| BADGE derivatives** | 2,2',6,6'-Tetrachlorobisphenol A (TraTBA) | | | | | |
| Bisphenol AF (BPAF) | 4-n-Nonylphenol | | | | | |
| Bisphenol B | 3,3',5-Trichlorobisphenol A (TrCBA)*** | | | | | |
| Organophosphate esters | | | | | | |
| 2,2-Bis(chloromethyl) propane-1,3-diyltetrakis(2- | Tris(2-butoxyethyl) phosphate (TBOEP) | | | | | |
| chloroethyl) bisphosphate (V6) | | | | | | |
| 2-Ethylhexyl diphenyl phosphate (EHDPP) | Tris(2-ethylhexyl) phosphate (TEHP) | | | | | |
| Bis(2-ethylhexyl) phosphate (BEHP) | | | | | | |
| Perfluoroalkyl substances | | | | | | |
| Perfluorobutanoic acid (PFBA) | Perfluorotridecanoic acid (PFTrDA) | | | | | |
| Perfluorohexanoic acid (PFHxA) | Perfluorooctadecanoic acid (PFODA)*** | | | | | |
| Perfluoropentanoic acid (PFPeA) | erfluoropentanoic acid (PFPeA) | | | | | |
| Pesticides | | | | | | |
| Azoxystrobin | Neonicotinoids** | | | | | |
| Benomyl | Propiconazole | | | | | |
| Captan | Pyrimethanil | | | | | |
| Chlorpropham | Tebuconazole | | | | | |
| Cyprodinil | Difenoconazole*** | | | | | |
| Dicloran | Metribuzin*** | | | | | |
| Glyphosate** | Pyraclostrobin*** | | | | | |
| Iprodione | Tetraconazole*** | | | | | |
| Metalaxyl | Triclopyr*** | | | | | |

Multi-class chemicals: Phthalate metabolites including replacement phthalates, environmental phenols including novel bisphenols, organophosphate esters, hydroxyl PAHs and current use pesticides

Multi-Class Chemical Biomarker Panel (n=121)

Phthalates and other plasticizers (n=45): 37 metabolites of 25 parent compounds: dimethyl phthalate, diethyl phthalate, diiso-propylphthalate, dipropylphthalate, di-iso-butyl phthalate, dibutyl phthalate, dipentyl phthalate, di-n-hexyl phthalate, di-octylphthalate, benzylbutyl phthalate, di-n-heptylphthalate, di-n-octyl phthalate, di-2-ethylhexyl phthalate, di-isodecylphthalate, di-iso-nonyl phthalate, di-iso-nonyl-cyclohexane-1,2-dicarboxy, di-(2-propylheptyl) phthalate, diethyl terephthalate, di-tert-butyl terephthalate, dibenzyl terephthalate, tri-n-butyl phosphate, tri-iso-butyl phosphate, triphenyl phosphate, trimethylphenyl phosphate, tris(1,3-dichloro-2-propyl) phosphate; 9 parent compounds: mono-benzyl terephthalate, triethyl phosphate, tri-n-butyl phosphate, tri-iso-butyl phosphate, tris(2-chloroethyl) phosphate, tripropyl phosphate, triphenyl phosphate, tris(2-butoxyethyl) phosphate, phthalic acid Phenols (n=45); 6 parabens (methyl, ethyl, n-propyl, n-butyl, benzyl, and heptyl); 6 benzophenones (1, 2, 3, 6, 8 and 4hyroxy), 2 trichlorophenols (2,4,5 and ,2,4,6), 3 tetrachlorphenols (2,3,5,6; 2,3,4,6; and 2,3,4,5), pentachlorophenol, BPA and 10 replacements (BPF, BPS, BPB, BPZ, BPAP, BPAF, BPP, TBBPA, TCBPA, TeCBPA), 3 BADGEs, triclocarban, triclosan, 2 metabolites of naphthalene (1-hydroxynaphthalene, 2-hydroxynaphthalene), 3 metabolites of fluorene (2-hydroxyfluorene, 3-hydroxyfluorene, 9-hydroxyfluorene), 5 metabolites of phenanthrene (1, 2, 3, 9, 4-hydroxyphenanthrene) Pesticides (n=31); nitenpyram, thiamethoxam, imidacloprid, acetamiprid, thiacloprid, clothianidin, flonicamid, Ndesmethyl, thiamethoxam, N-desmethyl-acetamiprid, thiacloprid-amide, imidaclothiz, 6-chloronicotinic acid, sulfoxaflor, 4nitrophenol, 2,4-dichlorophenoxyacetic acid, 3,5,6-trichloro-2-pyridinol, trans-3-(2,2-di-chlorovinyl)-2,2-dimethyl cyclopropane-1-carboxylic acid, cis-3-(2,2-di-chlorovinyl)-2,2-dimethyl-cyclopropane-1-carboxylic acid, 3-phenoxybenzoic acid, 4-fluoro-3-phenoxybenzoic acid, 2,4,5-trichlorophenoxyacetic acid, pyrimethanil, dinotefuran, metribuzin, atrazine, cyprodinil, metalaxyl, tebuconazole, propiconazole, tetraconazole, azoxystrobin



Develop a comprehensive high throughput analytical method to measure a multi-class environmental chemicals in urine (saves time and cost and samples)

- Ultra trace levels (pg to ng concentrations) quantitation
- Lack of analytical standards and internal standards
- Toxico-kinetics not known; what is the right biomarker?
- Multi-class: Challenging due to different functional groups, solubility, polarity and ionizability
- Cost of analysis (multi-class methods reduce cost and time)

Steps in analytic method development

- Acquire standards: native and labelled internal standards
- Infuse standards and build a <u>mass spec method</u> (GC/LC/mass spec amenability)
- Optimize <u>liquid chromatographic method</u> (column, mobile phase, additives, pH)
- Develop a robust extraction and purification (sample preparation method)
- Optimize analytical parameters for traceability, accuracy, precision, sensitivity and selectivity
- Validate the method; PT samples, SRMs, interlab studies



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Quality assurance and harmonization for targeted biomonitoring measurements of environmental organic chemicals across the Children's Health Exposure Analysis Resource laboratory network

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MS/MS method

AB SCIEX QTRAP 5500+ triple quadrupole; Exion LC

Example of first 45 chemicals Details for other chemicals are found on the published paper; JCA 1646 (2021).

Negative and positive ionization modes simultaneously; 2 mass spec methods



Compound name, abbreviation, CAS number, MRM (quantification) transition, collision energy (CE), method classification (MC), and retention time (RT) for 121 target compounds analyzed in the present study.

| Plasticiz and metabolities PM 8476-18-5 1757 -25 MSML NEG 3.77 1 mono-entityl phthalate mP 4376-18-5 175.77 -25 MSML NEG 5.58 3 mono-entityl phthalate mP 2306-33.4 193.57.7 -25 MSML NEG 5.59 6 mono-broypl phthalate mP 4376-18-5 207.77 -25 MSML NEG 6.34 7 mono-broypl phthalate mP 4376-19-6 231.57.7 -25 MSML NEG 6.34 8 mono-broypl phthalate mP 24339-57-8 235.77 -25 MSML NEG 6.95 9 mono-facyl phthalate mRP 24339-57-8 235.77 -25 MSML NEG 6.76 10 mono-2-ctarboxpropht phthalate mRP 2528-16-7 251.83 -16 MSML NEG 6.76 11 mono-2-thepyl phthalate mOP 539.19-1 277.12.5 -20 MSML NEG 6.70 12 mono-2-thepyl phthalate m | No. | Compound name | Synonym | CAS number | QT | CE | MC | RT | |
|---|------------------------------|---|---------|---------------|-------------|-----|----------|------|--|
| 1 phthalia and phthalate PA 88-90-3 165-77 -25 MSMI_NEG 3.77 2 mono-entryl phthalate mIP 2306-33-4 193-77 -25 MSMI_NEG 5.59 4 mono-sproyd phthalate mIPP 4376-18-5 207-77 -25 MSMI_NEG 5.57 5 mono-proyd phthalate mIPP 4376-18-6 207-77 -25 MSMI_NEG 5.67 6 mono-broyd phthalate mIPP 3033-35-2 231-77 -25 MSMI_NEG 6.40 8 mono-broyd phthalate mIPP 24539-56-8 235-77 -25 MSMI_NEG 6.40 9 mono-broyd phthalate mCPP 66851-46-5 251-103 -25 MSMI_NEG 6.40 10 mono-ctry phthalate mCPP 539-18-1 277-125 -20 MSMI_NEG 8.66 11 mono-ctry phthalate mCPP 539-18-1 277-134 -21 MSMI_NEG 8.66 12 mono-ctry phthalate mC | Plasticizers and metabolites | | | | | | | | |
| 2 none-nethyl phthalate mMP 4376-18-5 179-77 -25 MSML_NEG 4.37 4 mone-stopropyl phthalate mIPrP 4376-19-6 207-77 -25 MSML_NEG 5.59 5 mone-propyl phthalate mIPrP 4376-19-6 207-77 -25 MSML_NEG 5.77 6 mone-propyl phthalate mIPrP 4376-19-6 221-77 -25 MSML_NEG 6.34 7 mone-putyl phthalate mIPP 24539-57-9 249-77 -25 MSML_NEG 6.65 9 mone-benzyl phthalate mIPP 2258-16-5 235-77 -25 MSML_NEG 6.62 11 mone-chardoxypropyl phthalate mIPP 2217-17 -25 MSML_NEG 6.62 12 mone-chardoxypropyl phthalate mIPP 2371-103-5 257 -25 MSML_NEG 6.62 14 mone-(2-etityl-stynthalate mIPP 31047-64-0 305-155 -25 MSML_NEG 6.29 15 mone-(2-etityl-stynthalate <td>1</td> <td>phthalic acid</td> <td>PA</td> <td>88-99-3</td> <td>165>77</td> <td>-25</td> <td>MSM1_NEG</td> <td>3.77</td> | 1 | phthalic acid | PA | 88-99-3 | 165>77 | -25 | MSM1_NEG | 3.77 | |
| 3 mono-ethy phthalate mEP 2306-384 193-77 -25 MSML.NEG 5.06 5 mono-ne-propy phthalate mPrP 4376-18-5 207-77 -25 MSML.NEG 5.77 6 mono-ne-propy phthalate mPrP 4376-18-5 221-77 -25 MSML.NEG 6.40 7 mono-budy phthalate mPrP 24539-56-8 235-77 -25 MSML.NEG 6.40 10 mono-f-acrobaryporphthalate mRP 24539-57-8 235-77 -25 MSML.NEG 6.40 11 mono-benty phthalate mRP 24539-57-8 235-77 -25 MSML.NEG 6.47 12 mono-2-acrobyporphthalate mRP 2577-17 -25 MSML.NEG 6.63 14 mono-C2-ethylphthalate mPP 2301-77 25 MSML.NEG 6.52 15 mono-(2-ethylphthalate mPP 4376-20-9 277-134 -21 MSML.NEG 6.52 16 mono-(2-ethylphthalate mEHP 4376-20-9< | 2 | mono-methyl phthalate | mMP | 4376-18-5 | 179>77 | -25 | MSM1_NEG | 4.37 | |
| 4 mono-isoprogrip inthalate mIPP 4376-19-5 207-77 -25 MSM1_NEG 5.57 6 mono-isoprogrip inthalate mIBP 9033-53-5 221.77 -25 MSM1_NEG 6.40 7 mono-budy inthalate mBP 131-70-4 221.57 -25 MSM1_NEG 6.40 8 mono-pentyl phthalate mPP 24539-57-8 235-77 -25 MSM1_NEG 6.40 10 mono-jca-carboxypropyl phthalate mRP 24539-57-9 249-77 -25 MSM1_NEG 6.40 11 mono-betray inthalate mRP 2361-16-7 255-133 -16 MSM1_NEG 6.76 12 mono-c2-ettyl-phthalate mOP 539-91-1 277-154 -20 MSM1_NEG 6.52 13 mono-(2-ettyl-s-oxohexyl) phthalate mOP 539-17 -25 MSM1_NEG 6.52 16 mono-(2-ettyl-s-oxohexyl) phthalate mOP 139-121 -25 MSM1_NEG 6.39 16 mono-(2-ettyl-s-oxohexyl) phthalate <td>3</td> <td>mono-ethyl phthalate</td> <td>mEP</td> <td>2306-33-4</td> <td>193>77</td> <td>-25</td> <td>MSM1_NEG</td> <td>5.06</td> | 3 | mono-ethyl phthalate | mEP | 2306-33-4 | 193>77 | -25 | MSM1_NEG | 5.06 | |
| 5 mono-n-group phthalate mPP 4376-19-6 207-77 -25 MSML NEG 5.7. 6 mono-boulty phthalate mBP 30833-53-5 2211-77 -25 MSML NEG 6.34 7 mono-buty phthalate mBP 1270-64 2215-77 -25 MSML NEG 6.35 9 mono-bexy phthalate mRP 24539-57-8 249-77 -25 MSML NEG 7.40 10 mono-bexy phthalate mRP 6851-46-5 251-103 -25 MSML NEG 6.47 11 mono-chexy phthalate mHp 1271-125 200 MSML NEG 6.47 12 mono-2cleytiphthalate mHp 1271-125 -20 MSML NEG 6.29 14 mono-2cleytiphthalate mEOHP 40321-98-0 277-134 -21 MSML NEG 6.29 15 mono-2cleytiphthalate mEOP 4000-41-4 305-155 -25 MSML NEG 6.29 16 mono-2cleytiphthalate mEOP 4000-41-4 | 4 | mono-isopropyl phthalate | mIPrP | 4376-18-5 | 207>77 | -25 | MSM1 NEG | 5,59 | |
| 6 mono-sobury pithalate mBP 3083-53-5 221-77 -25 MSML_NEG 6.40 8 mono-pentyl pithalate mPP 24530-57-8 235-77 -25 MSML_NEG 6.40 9 mono-hexyl pithalate mEvP 24530-57-8 235-77 -25 MSML_NEG 6.40 10 mono-3c-arboxypropyl pithalate mEvP 24530-57-9 249-77 -25 MSML_NEG 6.46 11 mono-bentyl pithalate mEvP 258-167-7 -25 MSML_NEG 6.47 12 mono-Carbergyl pithalate mEVP 2633-77 -25 MSML_NEG 7.62 13 mono-C2-ettyl-f-bydroxphotyl pithalate mOP 539-19-1 277-142 -20 MSML_NEG 6.52 16 mono-(2-ettyl-f-bydroxphotyl pithalate mEHP 40321-99-1 293-121 -25 MSML_NEG 6.39 17 mono-carboxy-snootyl pithalate mECP 40809-41-4 307-159 -25 MSML_NEG 6.49 18 mono-2-cettyl-stro | 5 | mono-n-propyl phthalate | mPrP | 4376-19-6 | 207>77 | -25 | MSM1_NEG | 5.77 | |
| 7 mono-buryt phthalate mBP 113.70-4 221.77 -25 MSM1_NEG 6.95 9 mono-hexyt phthalate mCPP 24339-57-9 249.77 -25 MSM1_NEG 7.40 10 mono-bexyt phthalate mCPP 6681-46-5 225.71 -25 MSM1_NEG 4.56 11 mono-berxyt phthalate mBPP 1271-10-5 263.77 -25 MSM1_NEG 6.47 12 mono-Cytr phthalate mBPP 1277-125 -20 MSM1_NEG 6.80 14 mono-(2-ethyt-Sonbexyt) phthalate mEHP 4321-99-0 277-134 -21 MSM1_NEG 6.29 15 mono-(2-ethyt-Sonbexyt) phthalate mEHP 40321-98-0 293-121 -25 MSM1_NEG 6.83 19 mono-2-ethyt-Sonbexyt) phthalate mEVP 4009-41-4 307-159 -25 MSM1_NEG 7.60 20 mono-carboxy-isoortyl phthalate mCMP 898544-0-0 307-159 -25 MSM1_NEG 7.60 21 mono- | 6 | mono-isobutyl phthalate | mIBP | 30833-53-5 | 221>77 | -25 | MSM1 NEG | 6.34 | |
| 8 mono-penul phthalate mPeP 24539-95-8. 235>77 -25 MSM LNEG 6.97 9 mono-lexcyl phthalate mCPP 66851-46-5 251>103 -25 MSM LNEG 4.56 11 mono-benzyl phthalate mBzP 2528-16-7 255>183 -16 MSM LNEG 4.56 12 mono-2-teptyl phthalate mDP 533-19-1 277>125 -20 MSM LNEG 7.62 13 mono-(2-etthyl-5-vobnexyl) phthalate mDP 533-19-1 277>125 -20 MSM LNEG 7.80 14 mono-(2-etthyl-5-vobnexyl) phthalate mDHP 40321-99-1 293>121 -25 MSM LNEG 6.52 15 mono-(2-etthyl-5-vobnexyl) phthalate mDHP 4030-44-4 307>159 -25 MSM LNEG 6.63 16 mono-(2-etthyl-5-vobnexyl) phthalate mCMP 82975-93-7 307>159 -25 MSM LNEG 6.70 21 mono-chroxy-isoonryl phthalate mCIOP 889544-00-3 37>159 -25 MSM LNEG 6.70< | 7 | mono-butyl phthalate | mBP | 131-70-4 | 221>77 | -25 | MSM1 NEG | 6.40 | |
| 9 mono-locy phthalate mKP 24539-57-9 249-77 -25 MSMI_NEG 7.40 10 mono-benzy phthalate mDP 6351-46-5 251-103 -25 MSMI_NEG 6.45 11 mono-benzy phthalate mDP 2528-16-7 255-113 -16 MSMI_NEG 7.62 13 mono-cyth phthalate mDP 5393-19-1 277-125 -20 MSMI_NEG 7.89 14 mono-(2-ethyl-S-xobexyl) phthalate mEHP 40321-98-0 291-121 -25 MSMI_NEG 6.52 15 mono-(2-ethyl-S-xobexyl) phthalate mEHP 40321-99-1 293-121 -26 MSMI_NEG 6.52 16 mono-(2-ethyl-S-tydroxyhexyl) phthalate mCHP 40809-41-4 307-159 -25 MSMI_NEG 6.62 10 mono-carboxy-isooctyl phthalate mCHP 85686-57-3 307-159 -25 MSMI_NEG 6.62 20 mono-carboxy-isooctyl phthalate mCHP 85584-09-7 312-173 -20 MSMI_NEG 6.67 <td>8</td> <td>mono-pentyl phthalate</td> <td>mPeP</td> <td>24539-56-8</td> <td>235>77</td> <td>-25</td> <td>MSM1 NEG</td> <td>6.95</td> | 8 | mono-pentyl phthalate | mPeP | 24539-56-8 | 235>77 | -25 | MSM1 NEG | 6.95 | |
| 10 mone (3-carboxy propyl) phthalate mCPP 66851-46-5 251-103 -25 MSM_NEG 4.56 11 mone-benzyl phthalate mHpP 129171-03-5 263-77 -25 MSM_NEG 6.47 13 mone-octyl phthalate mHP 13717-03-5 263-77 -25 MSM_NEG 7.63 14 mone-(2-ettylk-forwyl) phthalate mEHP 4376-20-9 277-124 -21 MSM_NEG 6.29 15 mone-(2-ettylk-forwyl) phthalate mEOHP 40321-99-0 291-121 -25 MSM_NEG 6.29 16 mone-(2-ettyl-f-scaboxyentyl) phthalate mEOHP 40321-99-1 293-121 -26 MSM_NEG 6.39 18 mone-(2-ettyl-f-scaboxyentyl) phthalate mCMHP 82675-93-7 307-159 -25 MSM_NEG 6.49 21 mone-carboxy-isoontyl phthalate mCHP 82669-57-3 307-159 -25 MSM_NEG 6.49 22 mone-carboxy-isoontyl phthalate mCHP 83644-00-7 321-173 -20 MSM_NEG <td>9</td> <td>mono-hexyl phthalate</td> <td>mHxP</td> <td>24539-57-9</td> <td>249>77</td> <td>-25</td> <td>MSM1 NEG</td> <td>7.40</td> | 9 | mono-hexyl phthalate | mHxP | 24539-57-9 | 249>77 | -25 | MSM1 NEG | 7.40 | |
| Interpretation mBzP 2528-16-7 255-183 16 MSM_NEG 6.47 12 mono-2-heptyl phthalate mHpP 129171-03-5 263-77 -25 MSM1_NEG 7.62 13 mono-cityl phthalate mDP 5393-19-1 2777-125 -20 MSM1_NEG 7.82 14 mono-(2-ettyl-5-xohexyl) phthalate mEHP 4376-20-9 277-134 -21 MSM1_NEG 6.52 15 mono-(2-ettyl-5-xohexyl) phthalate mEHP 43021-99-1 293-121 -26 MSM1_NEG 6.52 16 mono-(2-cttyl-5-xohoxypenyl) phthalate mECP 4080-41-4 307-159 -25 MSM1_NEG 6.39 19 mono-carboxy-isoocyl phthalate mCMPP 85666-57-3 307-159 -25 MSM1_NEG 7.60 20 mono-carboxy-isoocyl phthalate mCIOP 898544-09-7 317-159 -25 MSM1_NEG 6.67 21 mono-carboxy-isoocyl phthalate mHIP 1373125-39-9 315-187 -21 MSM1_NEG 6.67 | 10 | mono-(3-carboxypropyl) phthalate | mCPP | 66851-46-5 | 251>103 | -25 | MSM1 NEG | 4.56 | |
| 12 mono-2-hepyl phthalate mHpP 129171-03-5 263>77 -25 MSH_PEG 7.62 13 mono-Q-ethyl phthalate mOP 3933-19-1 277>125 -20 MSM1_NEG 7.63 14 mono-(2-ethyl-5-cxohexyl) phthalate mEHP 4376-20-9 277>134 -21 MSM1_NEG 7.89 15 mono-(2-ethyl-5-cydroxylyl) phthalate mEHP 40321-99-0 293-121 -25 MSM1_NEG 6.52 16 mono-(2-ethyl-5-tydroxyneyl) phthalate mECP 40809-41-4 305-155 -25 MSM1_NEG 6.39 19 mono-(2-cathoxyneptyl) phthalate mCHP 8297-93-7 307-159 -25 MSM1_NEG 6.70 20 mono-catroxy-socryl phthalate mCIP 83684-09-7 315-17 -20 MSM1_NEG 6.67 21 mono-catroxy-socryl phthalate mCINP 898544-10-0 307-159 -25 MSM1_NEG 7.30 24 mono-dydroxy-isononyl phthalate mCINP 1373125-92-8 315-187 -21 MSM1_NE | 11 | mono-benzyl phthalate | mBzP | 2528-16-7 | 255>183 | -16 | MSM1 NEG | 6.47 | |
| 13 mono-cityl phthalate mOP 5393-19-1 277-125 -20 MSN1_NEG 8.03 14 mono-(2-ettyl-scohexyl) phthalate mEHP 4376-20-9 277-134 -21 MSN1_NEG 7.89 15 mono-(2-ettyl-S-tydroxyhexyl) phthalate mEHP 40321-99-1 293-121 -26 MSN1_NEG 6.29 16 mono-(2-ettyl-S-tydroxyhexyl) phthalate mEHP 40321-99-1 203-121 -26 MSN1_NEG 6.39 18 mono-(2-ettyl-S-carboxypentyl) phthalate mECP 40809-41-4 307-159 -25 MSN1_NEG 6.39 19 mono-(7-carboxyhetyl) phthalate mCHP 858669-57-3 307-159 -25 MSN1_NEG 6.49 21 mono-carboxy-isoontyl phthalate mCIOP 898544-09-7 321-17 -20 MSN1_NEG 7.30 23 2-(((9-bydroxy-isononyl phthalate mCIOP 1373125-93-9 335-187 -21 MSN1_NEG 7.30 24 monohydroxy-isononyl phthalate mCIOP 1373125-93-9 335-187 - | 12 | mono-2-heptyl phthalate | mHpP | 129171-03-5 | 263>77 | -25 | MSM1 NEG | 7.62 | |
| 14 mono-(2-ettyl)-bashlate mEHP 4376-20-9 277-134 -21 MSMI_NEG 7.89 15 mono-(2-ettyl)-5-oxohexyl) phthalate mEOHP 40321-99-0 291>121 -26 MSMI_NEG 6.29 16 mono-(2-ettyl)-5-cohoxyl) phthalate mIDP 31047-64-0 305-155 -25 MSMI_NEG 6.39 17 mono-(2-ettyl)-5-carboxypentyl) phthalate mCP 40809-41-4 307-159 -25 MSMI_NEG 6.39 19 mono-(2-ettyl)-5-oxolexypentyl) phthalate mCMP 8295-93-7 307-159 -25 MSMI_NEG 6.49 21 mono-carboxy-isoorcyl phthalate mCIOP 898544-09-7 307-159 -25 MSMI_NEG 7.06 23 2-((()-phydroxyderychyloxy)-carboxyloxplothonyl benzoic acid mHiNP notavailable 321-121 -25 MSMI_NEG 7.00 24 mono-draboxy-isononyl phthalate mCIOP 898544-10-0 307-121 -25 MSMI_NEG 7.00 25 cyclohexane-1.2-dicarboxylic acid-mono (bydroxy-isononyl) etter mHINCH 1637562-52-7 313.3-153 -25 MSMI_NEG 7.00 <td>13</td> <td>mono-octyl phthalate</td> <td>mOP</td> <td>5393-19-1</td> <td>277>125</td> <td>-20</td> <td>MSM1 NEG</td> <td>8.03</td> | 13 | mono-octyl phthalate | mOP | 5393-19-1 | 277>125 | -20 | MSM1 NEG | 8.03 | |
| 15 mono-(2-ethyl-5-oxohexyl) phthalate mEOHP 40321-98-0 291>121 -25 MSM_NEG 6.29 16 mono-(2-ethyl-5-hydroxyhexyl) phthalate mEHHP 40321-99-1 293>121 -26 MSM_NEG 6.52 17 mono-isodecyl phthalate mIDP 31047-64-0 305>155 -25 MSM_NEG 6.39 18 mono-(2-cthyl-5-carboxypentyl) phthalate mCMHP 82075-93-7 307>159 -25 MSM_NEG 6.49 20 mono-carboxy-isoontyl phthalate mCHP 82684-09-7 312>173 -20 MSM_NEG 7.60 21 mono-carboxy-isoontyl phthalate mCINP 83544-09-7 312>171 -20 MSM_NEG 7.80 24 mono-tarboxy-isoontyl phthalate mHINP not available 321>121 -35 MSM_NEG 7.40 25 cyclohexane-1,2-dicarboxylic acid-mono (hydroxy-isononyl) ester mHNCH 158520-62-0 311.4-153 -25 MSM_NEG 7.30 26 cyclohexane-1,2-dicarboxylic acid-mono (xoxo-isononyl) ester mOOH <t< td=""><td>14</td><td>mono-(2-ethylhexyl) phthalate</td><td>mEHP</td><td>4376-20-9</td><td>277>134</td><td>-21</td><td>MSM1_NEG</td><td>7.89</td></t<> | 14 | mono-(2-ethylhexyl) phthalate | mEHP | 4376-20-9 | 277>134 | -21 | MSM1_NEG | 7.89 | |
| 16 mono-(2-ethyl-5-hydroxyhexyl) phthalate mEHHP 40321-99-1 293>121 -26 MSM_NEG 6.52 17 mono-isodecyl phthalate mIDP 31047-64-0 305>155 -25 MSM_NEG 8.39 18 mono-(2-ethyl-5-carboxypenyl) phthalate mCPP 4809-41-4 307>159 -25 MSM_NEG 7.00 20 mono-(2-ethyl-5-carboxypenyl) phthalate mCHP 82975-93-7 307>159 -25 MSM_NEG 6.49 21 mono-carboxy-isonoryl phthalate mCIOP 898544-09-7 321>173 -20 MSM_NEG 7.16 23 2-(((g-hydroxydecyl)oxy)carbonyl) benzoic acid mHiDP not available 321>121 -35 MSM_NEG 7.30 24 monolydroxy-isonoryl phthalate mHNP 898544-10-0 307>121 -25 MSM_NEG 7.40 25 cyclohexane-1,2-dicarboxylic acid-mono (bydroxy-isonoryl) ester mNOKH 1637562-52-7 313,3-153 -25 MSM_NEG 7.30 26 cyclohexane-1,2-dicarboxylic acid-mono coxo-isonoryl mono-2/mory | 15 | mono-(2-ethyl-5-oxohexyl) phthalate | mEOHP | 40321-98-0 | 291>121 | -25 | MSM1_NEG | 6.29 | |
| 17 mono-isodecyl phthalate mIDP 31047-64-0 305>155 -25 MSM1_NEG 8.39 18 mono-(2-cerbityl-5-carboxypentyl) phthalate mC(HP 40809-41-4 307>159 -25 MSM1_NEG 7.00 20 mono-(2-carboxyhentyl) phthalate mC(HP 82975-93-7 307>159 -25 MSM1_NEG 7.00 20 mono-carboxy-isooctyl phthalate mC(HP 898544-00-7 321>173 -20 MSM1_NEG 7.16 21 mono-carboxy-isoontyl phthalate mC(HP 898544-10-3 335>187 -21 MSM1_NEG 7.16 23 2-(((9-hydroxydecyl)oxy) carbonyl) benzoic acid mHiNP moto-stoce acid mHiNP 898544-10-3 307>121 -25 MSM1_NEG 7.40 24 monolydroxy-isoononyl phthalate mHNCH 1637562-52-7 313.3>153 -25 MSM1_NEG 7.40 25 cyclohexane-1,2-dicarboxylic acid-mono (xoz-isononyl) ester mNCH 1588520-62-0 311.4>153 -25 MSM1_NEG 7.08 26 cyclohexane-1,2-dicarboxy | 16 | mono-(2-ethyl-5-hydroxyhexyl) phthalate | mEHHP | 40321-99-1 | 293>121 | -26 | MSM1_NEG | 6.52 | |
| 18 mono-(2-ethyl-5-carboxypentyl) phthalate mECPP 40809-41-4 307-159 -25 MSM1_NEG 6.39 19 mono-(2-carboxymetyl) phthalate mCMIP 82975-93-7 307-159 -25 MSM1_NEG 6.39 20 mono-(7-carboxymetyl) phthalate mCHP 85680-57-3 307-159 -25 MSM1_NEG 6.49 21 mono-carboxy-isoocyl phthalate mCIOP 898544-09-7 321-173 -20 MSM1_NEG 6.77 23 2-((I)e-hydroxydey(I)oxy)corboyl) benzoic acid mHIDP not available 321-121 -35 MSM1_NEG 7.30 24 monohydroxy-isononyl phthalate mHIDP not available 307-121 -25 MSM1_NEG 7.30 25 cyclohexane-1,2-dicarboxylic acid-mono (bydroxy-isononyl) ester mNCH 1637562-52-7 313.3 >153 -25 MSM1_NEG 7.20 26 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mONCH 1588520-62-0 311.4 >153 -22 MSM1_NEG 7.28 29 cyclohexane-1,2-dicarboxyl-hexyl-phthalat | 17 | mono-isodecyl phthalate | mIDP | 31047-64-0 | 305>155 | -25 | MSM1_NEG | 8.39 | |
| 19 mono-[2-(carboxymethyl)hexyl] phthalate mCMHP 82975-93-7 307 > 159 -25 MSM1_NEG 7.00 20 mono-(7-carboxyheryl) phthalate mCIP 858669-57-3 307 > 159 -25 MSM1_NEG 6.49 21 mono-carboxy-isooxtl phthalate mCIP 898544-00-7 321 > 173 -20 MSM1_NEG 7.16 22 mono-carboxy-isononyl phthalate mCIP 1373125-93-9 335 > 187 -21 MSM1_NEG 7.16 24 monohydroxy-isononyl phthalate mCINP 1373125-93-9 335 > 187 -25 MSM1_NEG 7.40 24 monohydroxy-isononyl phthalate mHNP 137325-92-8 313.3 > 153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono (xoz-isononyl) ester mONCH 1588520-62-0 311.4 > 153 -25 MSM1_NEG 7.40 27 mono-2-(propyl-6-oxhoptyl)-phthalate mPOHP 137125-92-8 319.3 > 121.1 -22 MSM1_NEG 7.16 28 mono-2-(propyl-6-chydroxy-hexyl)-phthalate mPOHP | 18 | mono-(2-ethyl-5-carboxypentyl) phthalate | mECPP | 40809-41-4 | 307>159 | -25 | MSM1_NEG | 6.39 | |
| 20 mono-(7-carboxyheptyl) phthalate mCHpP 856869-57-3 307>159 -25 MSM1_NEG 6.49 21 mono-carboxy-isoontyl phthalate mCIOP 898544-09-7 321>173 -20 MSM1_NEG 6.77 22 mono-carboxy-isoontyl phthalate mCINP 1973125-03-9 335>187 -21 MSM1_NEG 7.16 23 2-(((9-hydroxydecyl)oxy)carbonyl) benzoic acid mHiNP 898544-10-0 307>151 -25 MSM1_NEG 7.30 24 monohydroxy-isoonnyl phthalate mHNCH 1873562-52-7 313.3>153 -25 MSM1_NEG 7.40 25 cyclohexane-1,2-dicarboxylic acid-mono (xox-isononyl) ester mHNCH 1637562-52-7 313.3>153 -25 MSM1_NEG 7.20 26 cyclohexane-1,2-dicarboxylic acid-mono carboxy isooctyl ester mONCH 158520-62-0 311.4>153 -25 MSM1_NEG 7.28 27 mono-2-(propyl-6-bydroxy-heptyl)-phthalate mPCHP 1412411-10-9 332.121.1 -22 MSM1_NEG 7.28 30 mono-etryl trephthalate | 19 | mono-[2-(carboxymethyl)hexyl] phthalate | mCMHP | 82975-93-7 | 307>159 | -25 | MSM1 NEG | 7.00 | |
| 21 mono-carboxy-isooctyl pithalate mCIOP 898544-09-7 321 > 173 -20 MSM1_NEG 6.77 22 mono-carboxy-isoonyl pithalate mCINP 1373125-93-9 355-187 -21 MSM1_NEG 7.16 23 2-(((9-hydroxy-isononyl pithalate mHiNP 898544-10-0 307>121 -35 MSM1_NEG 6.95 24 monohydroxy-isononyl pithalate mHiNP 898544-10-0 307>121 -25 MSM1_NEG 6.95 25 cyclohexane-1,2-dicarboxylic acid-mono (hydroxy-isononyl) ester mHNCH 1637562-52-7 313.3-153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono coxo-isononyl ester mONCH 1588520-62-0 311.4>153 -25 MSM1_NEG 7.08 28 mono-2-(propyl-6-hydroxy-hepryl)-phthalate mPHHP 1372605-11-2 321.2>12.1 -35 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxyhexylip phthalate mCCH 1637562-51-6 327.4>17.31 -22 MSM1_NEG 7.16 31 mono-etryl terephthalate | 20 | mono-(7-carboxyheptyl) phthalate | mCHpP | 856869-57-3 | 307>159 | -25 | MSM1_NEG | 6.49 | |
| 22 mono-carboxy-isononly phthalate mCINP 1373125-93-9 335>187 -21 MSM1_NEG 7.16 23 2-(((0-hydroxydecyl))oxy)carbonyl) benzoic acid mHiDP not available 321>121 -35 MSM1_NEG 7.30 24 monohydroxy-isononyl phthalate mHiNP 898544-10-0 307>121 -25 MSM1_NEG 7.40 25 cyclohexane-1,2-dicarboxylic acid-mono (hydroxy-isononyl) ester mHNCH 1637562-52-7 313.3-153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono (oxo-isononyl) ester mONCH 1588520-62-0 311.4-153 -25 MSM1_NEG 7.20 27 mono-2-(propyl-6-bydroxy-heptyl)-phthalate mPHP 1372655-15 327.4-173.1 -22 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxylic acid- monocarboxy isooctyl ester mCOH 1637562-51-6 327.4-173.1 -22 MSM1_NEG 7.16 31 mono-etryl terephthalate mETP 713-57-5 192.9-119.9 -28 MSM1_NEG 7.38 32 mono-te | 21 | mono-carboxy-isooctyl phthalate | mCIOP | 898544-09-7 | 321>173 | -20 | MSM1_NEG | 6.77 | |
| 23 2-((((9-hydroxydecyl)oxy)carbonyl) benzoic acid mHiDP not available 321>121 -35 MSM1_NEG 7.30 24 monohydroxy-isononyl phthalate mHiNP 898544-10-0 307>121 -25 MSM1_NEG 6.95 25 cyclohexane-1,2-dicarboxylic acid-mono (oxo-isononyl) ester mHNCH 1637562-52-7 313.3 153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono (oxo-isononyl) ester mONCH 158520-62-0 311.4>153 -25 MSM1_NEG 7.20 27 mono-2-(propyl-6-oxoheptyl)-phthalate mPOHP 1373125-92-8 319.3>121.1 -22 MSM1_NEG 7.28 29 cyclohexane-1,2-dicarboxylic acid-mono carboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.16 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mPCHP 1412411-10-9 335.3>187.3 -15 MSM1_NEG 7.18 31 mono-ethyl terephthalate mTBTP 20576-82-3 221>119.8 -30 MSM1_NEG 7.38 33 mono-berzyl terephthalate mBZTP 18520-63-3 255.3>119.9 | 22 | mono-carboxy-isononyl phthalate | mCINP | 1373125-93-9 | 335>187 | -21 | MSM1_NEG | 7.16 | |
| 24 monolydroxy-isononyl phthalate mHiNP 898544-10-0 307 > 121 -25 MSM1_NEG 6.95 25 cyclohexane-1,2-dicarboxylic acid-mono (xoc-isononyl) ester mHNCH 1637562-52-7 313.3-153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono (xoc-isononyl) ester mONCH 1588520-62-0 311.4>153 -25 MSM1_NEG 7.20 27 mono-2-(propyl-6-oxheptyl)-phthalate mPOHP 137125-92-8 319.3>121.1 -22 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.38 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mETP 713-57-5 192.9>119.9 -25 MSM1_NEG 7.18 31 mono-etnyl terephthalate mETP 713-57-5 192.9>119.9 -25 MSM1_NEG 7.38 34 triehyl phosphate TEP 78-40-0 183-99.1 35 MSM2_POS 3.09 35-1 triehyl phosphate TBP </td <td>23</td> <td>2-(((9-hvdroxvdecyl)oxv)carbonyl) benzoic acid</td> <td>mHiDP</td> <td>not available</td> <td>321>121</td> <td>-35</td> <td>MSM1_NEG</td> <td>7.30</td> | 23 | 2-(((9-hvdroxvdecyl)oxv)carbonyl) benzoic acid | mHiDP | not available | 321>121 | -35 | MSM1_NEG | 7.30 | |
| 25 cyclohexane-1,2-dicarboxylic acid-mono (hydroxy-isononyl) ester mHNCH 1637562-52-7 313.3>153 -25 MSM1_NEG 7.40 26 cyclohexane-1,2-dicarboxylic acid-mono (oxo-isononyl) ester mONCH 1588520-62-0 311.4>153 -25 MSM1_NEG 7.20 27 mono-2-(propyl-6-oxoheptyl)-phthalate mPOHP 1373125-92-8 319.3>121.1 -22 MSM1_NEG 7.30 29 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mCOH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.38 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mPCHP 1412411-10-9 335.3>187.3 -15 MSM1_NEG 7.16 31 mono-etnyl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 7.38 32 mono-tenzyl terephthalate mBTP 20576-82-3 221.>119.8 -30 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183.99.1 35 MSM2_POS 5.12 35-1 tri=hobutyl phosphate | 24 | monohydroxy-isononyl phthalate | mHiNP | 898544-10-0 | 307>121 | -25 | MSM1 NEG | 6.95 | |
| 26 cyclohexane-1,2-dicarboxylic acid-mono (xxo-isononyl) ester mONCH 1588520-62-0 311.4>153 -25 MSM1_NEG 7.20 27 mono-2-(propyl-6-oxoheptyl)-phthalate mPOHP 1373125-92-8 319.3>121.1 -22 MSM1_NEG 7.30 28 mono-2-(propyl-6-hydroxy-heptyl)-phthalate mPHHP 1372605-11-2 321.2>121 -35 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mCCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.36 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mPCHP 1412411-10-9 335.3>187.3 -15 MSM1_NEG 7.16 31 mono-etryl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 7.18 33 mono-benzyl terephthalate mBZTP 18520-63-3 255.3>119.9 -25 MSM1_NEG 7.30 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 3.09 35-1 tri-n-butyl phosphate TEP | 25 | cvclohexane-1.2-dicarboxylic acid-mono (hvdroxy-isononyl) ester | mHNCH | 1637562-52-7 | 313.3>153 | -25 | MSM1_NEG | 7.40 | |
| 27 mono-2-(propyl-6-oxoheptyl)-phthalate mPOHP 1373125-92-8 319.3>121.1 -22 MSM1_NEG 7.08 28 mono-2-(propyl-6-hydroxy-heptyl)-phthalate mPHHP 1372605-11-2 321.2>121 -35 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.16 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mCCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.28 31 mono-etnyl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 7.18 33 mono-herer-butyl terephthalate mETP 713-57-5 192.9>119.9 -25 MSM1_NEG 7.18 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 5.12 35-1 tri-n-butyl phosphate TNBP 126-73-8 267.1>99 22 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TPP 513-08-66 327.1>7 | 26 | cvclohexane-1.2-dicarboxylic acid-mono (oxo-isononyl) ester | mONCH | 1588520-62-0 | 311.4>153 | -25 | MSM1 NEG | 7.20 | |
| 28 mono-2-(propyl-6-hydroxy-heptyl)-phthalate mPHHP 1372605-11-2 321.2>121 -35 MSM1_NEG 7.31 29 cyclohexane-1,2-dicarboxylic acid-monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.31 30 mono-2-(propyl-6-carboxylic acid-monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.28 30 mono-2-(propyl-6-carboxylic acid-monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.28 31 mono-etryl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 7.18 32 mono-tertyl terephthalate mBZTP 18520-63-3 253.5>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TNBP 126-73-8 267.1>99 22 MSM2_POS 5.12 35-1 tri-n-butyl phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 3.42 36 tripropyl phosphate TPP <t< td=""><td>27</td><td>mono-2-(propyl-6-oxoheptyl)-phthalate</td><td>mPOHP</td><td>1373125-92-8</td><td>319.3>121.1</td><td>-22</td><td>MSM1 NEG</td><td>7.08</td></t<> | 27 | mono-2-(propyl-6-oxoheptyl)-phthalate | mPOHP | 1373125-92-8 | 319.3>121.1 | -22 | MSM1 NEG | 7.08 | |
| 29 cyclohexane-1,2-dicarboxylic acid monocarboxy isooctyl ester mCOCH 1637562-51-6 327.4>173.1 -22 MSM1_NEG 7.28 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mPCHP 1412411-10-9 335.3>187.3 -15 MSM1_NEG 7.16 31 mono-ethyl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 6.29 32 mono-tert-butyl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 7.18 34 triethyl phosphate mB2TP 18520-63-3 225.3>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 3.09 35-1 tri-n-butyl phosphate TCEP 78-40-0 183>99.1 35 MSM2_POS 3.09 37 triis(2-chitoroethyl) phosphate TCEP 115-96-8 284.9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 227.1>77.1 46 MSM2_POS 3.93 39 triphenyl phosphate TPP | 28 | mono-2-(propyl-6-hydroxy-heptyl)-phthalate | mPHHP | 1372605-11-2 | 321.2>121 | -35 | MSM1_NEG | 7.31 | |
| 30 mono-2-(propyl-6-carboxy-hexyl)-phthalate mPCHP 1412411-10-9 335.3>187.3 -15 MSM1_NEG 7.16 31 mono-ethyl terephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 6.29 32 mono-tert-butyl terephthalate mBTP 20576-82-3 221>119.8 -30 MSM1_NEG 7.18 33 mono-benzyl terephthalate mBZTP 18520-63-3 255.3>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 3.09 35-1 tri-n-butyl phosphate TBP 126-73-8 267.1>99 22 MSM2_POS 3.09 37 tris(2-chloroethyl) phosphate TCEP 115-96-8 284.9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 227.1>77.1 46 MSM2_POS 3.93 39 triphenyl phosphate TBOE 78-51-3 399.1 199 20 MSM2_POS 3.93 40 tris(2-butoxyethyl) phosphate DNBP 107-66-4 | 29 | cyclohexane-1.2-dicarboxylic acid- monocarboxy isooctyl ester | mCOCH | 1637562-51-6 | 327.4>173.1 | -22 | MSM1_NEG | 7.28 | |
| 31 mono-etr() trephthalate mETP 713-57-5 192.9>119.9 -28 MSM1_NEG 6.29 32 mono-tert-butyl trephthalate mTBTP 20576-82-3 221>119.8 -30 MSM1_NEG 7.18 33 mono-benzyl trephthalate mBZTP 18520-63-3 255.3>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TIBP 126-73-8 267.1>99 22 MSM2_POS 5.12 36 trijropyl phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 3.93 37 tris(2-chloroethyl) phosphate TPP 513-08-6 225.1>99 35 MSM2_POS 3.93 39 tripropyl phosphate TPP 115-86-6 327.1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.29 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 | 30 | mono-2-(propyl-6-carboxy-hexyl)-phthalate | mPCHP | 1412411-10-9 | 335.3>187.3 | -15 | MSM1_NEG | 7.16 | |
| 32 mono-tert-butyl terephthalate mTBTP 20576-82-3 221>119.8 -30 MSM1_NEG 7.18 33 mono-benzyl terephthalate mBZTP 18520-63-3 255.3>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 5.12 35-1 tri-n-butyl phosphate TNBP 126-73-8 267.1>99 22 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 225.1>99 35 MSM2_POS 3.42 39 triphenyl phosphate TPP 513-08-6 225.1>99 35 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TPP 513-08-6 327.1>77.1 46 MSM2_POS 4.98 41-1 di-n-butyl phosphate TBOEP 78-51-3 399.1>199 20 MSM1_NEG 6.28 41-2 | 31 | mono-ethyl terephthalate | mETP | 713-57-5 | 192.9>119.9 | -28 | MSM1_NEG | 6.29 | |
| 33 mono-benzyl terephthalate mBzTP 18520-63-3 255.3>119.9 -25 MSM1_NEG 7.38 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 3.09 35-1 tri-n-butyl phosphate TNBP 126-73-8 267.1>99 22 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 3.42 37 tris(2-chloroethyl) phosphate TCEP 115-96-8 284.9>63.1 40 MSM2_POS 3.93 39 triphosphate TCP 513-08-6 225.1>99 35 MSM2_POS 3.93 40 tris(2-butoxyethyl) phosphate TPhP 115-86-6 327.1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.22 41-1 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 41-2 | 32 | mono-tert-butyl terephthalate | mTBTP | 20576-82-3 | 221>119.8 | -30 | MSM1_NEG | 7.18 | |
| 34 triethyl phosphate TEP 78-40-0 183>99.1 35 MSM2_POS 3.09 35-1 tri-n-butyl phosphate TNBP 126-73-8 267,1>99 22 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TIBP 126-73-8 267,1>99 22 MSM2_POS 5.12 37 tris(2-chloroethyl) phosphate TCEP 115-96-8 284,9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 225,1>99 35 MSM2_POS 3.93 39 triphenyl phosphate TPP 513-08-6 327,1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TBOEP 78-51-3 399,1>199 20 MSM2_POS 5.51 41-1 di-n-butyl phosphate DNRP 107-66-4 209>78.9 -35 MSM1_NEG 6.92 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85-7 248,9>93.1 -40 MSM1_NEG | 33 | mono-benzyl terephthalate | mBzTP | 18520-63-3 | 255.3>119.9 | -25 | MSM1_NEG | 7.38 | |
| 35-1 tri-n-butyl phosphate TNBP 126-73-8 267.1>99 22 MSM2_POS 5.12 35-2 tri-isobutyl phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 5.12 37 tris(2-chloreethyl) phosphate TIBP 126-71-6 267.1>99 22 MSM2_POS 5.12 37 tris(2-chloreethyl) phosphate TPP 115-96-8 284.9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 327.1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TBOEP 78-51-3 399.1>199 20 MSM2_POS 5.51 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.29 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85-7 248.9>93.1 -40 MSM2_NEG 6.28 44 bis(1-3-methylphenyl) phosphate BMPP 37587-74-7 277.107 -40 | 34 | triethyl phosphate | TEP | 78-40-0 | 183>99.1 | 35 | MSM2 POS | 3.09 | |
| 35-2 tri-isobutyl phosphate TIBP 126-71-6 267,1>99 22 MSM2_POS 37 tris(2-chloroethyl) phosphate TCEP 115-96-8 284,9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 225,1>99 35 MSM2_POS 3.93 39 triphenyl phosphate TPP 513-08-6 327,1>77,1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TBOEP 78-51-3 399,1>199 20 MSM2_POS 4.98 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.92 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85-7 248,993.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 3578-74-7 277>107 -40 MSM2_NEG 1.74 45 bis(1.3 adichlore-2-promyl) phosphate BMCP 7236-72-7 316,9>35 -30 MSM2_NEG | 35-1 | tri-n-butyl phosphate | TNBP | 126-73-8 | 267.1>99 | 22 | MSM2_POS | 5.12 | |
| 37 tris(2-chloroethyl) phosphate TCEP 115-96-8 284.9>63.1 40 MSM2_POS 3.42 38 tripropyl phosphate TPP 513-08-6 225.1>99 35 MSM2_POS 3.93 39 triphenyl phosphate TPP 513-08-6 327.1>77.1 46 MSM2_POS 4.98 40 trig(2-butoxyethyl) phosphate TBOEP 78-51-3 399.1>199 20 MSM2_POS 5.51 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.22 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85-7 248.9>93.1 -40 MSM2_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 35787-74-7 277-107 -40 MSM2_NEG 6.28 45 bis(1 3-dichore-2-monwl) phosphate BMCP 72736-72-7 316.9>35 -30 MSM2_NEG 1.74 | 35-2 | tri-isobutyl phosphate | TIBP | 126-71-6 | 267.1>99 | 22 | MSM2_POS | | |
| 38 tripropyl phosphate TPP 513-08-6 225.1>99 35 MSM2_POS 3.93 39 triphenyl phosphate TPh 115-86-6 327.1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TBOEP 78-51-3 399.1>199 20 MSM2_POS 5.51 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.92 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85-7 248.9>93.1 -40 MSM1_NEG 6.28 44 bis(12-methylphenyl) phosphate BMPP 35787-74-7 277>107 -40 MSM2_NEG 2.66 45 bis(13-methylphenyl) phosphate BDCPUP 72356-72-7 316.9>35 -30 MSM2_NEG 1.74 | 37 | tris(2-chloroethyl) phosphate | TCEP | 115-96-8 | 284.9>63.1 | 40 | MSM2_POS | 3.42 | |
| 39 triphenyl phosphate TPhP 115–86–6 327.1>77.1 46 MSM2_POS 4.98 40 tris(2-butoxyethyl) phosphate TBOEP 78–51–3 399.1>199 20 MSM2_POS 5.51 41–1 di-n-butyl phosphate DNBP 107–66–4 209>78.9 -35 MSM1_NEG 6.92 41–2 di-isobutyl phosphate DIBP 6303-30–6 209>78.9 -35 MSM1_NEG 6.28 43 diphenyl phosphate DPhP 838-85–7 248.9>93.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 35787-74–7 277>107 -40 MSM2_NEG 2.66 45 bis(1-3 adtichore-2-promyl) phosphate B/CIPP 72356-72–7 316.9>.35 | 38 | tripropyl phosphate | TPP | 513-08-6 | 225.1>99 | 35 | MSM2 POS | 3.93 | |
| 40 tris(2-butoxyethyl) phosphate TBOEP 78-51-3 399.1>199 20 MSM2_POS 5.51 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.92 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 43 diphenyl phosphate DPhP 838-85-7 248.9>93.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 35787-74-7 277>107 -40 MSM2_NEG 2.66 45 bis(1 3-dichloro-2-prowyl) phosphate BDCIPP 72336-727-7 316.9>35 -30 MSM2_NEG 1.74 | 39 | triphenyl phosphate | TPhP | 115-86-6 | 327.1>77.1 | 46 | MSM2 POS | 4.98 | |
| 41-1 di-n-butyl phosphate DNBP 107-66-4 209>78.9 -35 MSM1_NEG 6.92 41-2 di-isobutyl phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 43 diphenyl phosphate DPhP 838-85-7 248.99.93.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 35787-74-7 277>107 -40 MSM2_NEG 6.26 45 bis(1.3-dichlore-2-propyl) phosphate BDCIPP 72366-72-7 316.9>35 -30 MSM2_NEG 1.74 | 40 | tris(2-butoxyethyl) phosphate | TROFP | 78-51-3 | 3991>199 | 20 | MSM2_POS | 5.51 | |
| 41-2 di-isobuty phosphate DIBP 6303-30-6 209>78.9 -35 MSM1_NEG 43 diphenyl phosphate DIBP 838-85-7 248.9>93.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMPP 35787-74-7 277>107 -40 MSM2_NEG 2.66 45 bis(1-3-dichore-2-propyl) phosphate BDCPP 72356-72-7 316.9>35 -30 MSM2_NEG 2.66 | 41-1 | di-n-butyl phosphate | DNBP | 107-66-4 | 209>78.9 | -35 | MSM1_NEG | 6.92 | |
| 43 diphenyl phosphate DPhP 838-85-7 248.9>93.1 -40 MSM1_NEG 6.28 44 bis(2-methylphenyl) phosphate BMP 35787-74-7 277>107 -40 MSM2_NEG 2.66 45 bis(1.3-dichloro-2-propyl) phosphate BDCIPP 7236-72-7 316 9-35 -30 MSM2_NEG 1.74 | 41-2 | di-isobutyl phosphate | DIBP | 6303-30-6 | 209>78.9 | -35 | MSM1_NEG | 0.02 | |
| 44 bis(2-methylphenyl) phosphate BMP 35787-74-7 277>107 -40 MSM2_NEG 2.66 45 bis(13-dichloro-2-propyl) phosphate BDCIPP 7236-72-7 316.9>35 -30 MSM2_NEG 174 | 43 | diphenyl phosphate | DPhP | 838-85-7 | 248.9>93.1 | -40 | MSM1_NEG | 6.28 | |
| 45 bis(1.3-dichloro-2-provl) phosphate BDCIPP 72236-72-7 316.9-35 - 30 MSM2_NEC 1.74 | 44 | bis(2-methylphenyl) phosphate | BMPP | 35787-74-7 | 277>107 | -40 | MSM2_NEG | 2.66 | |
| | -45 | bis(1.3-dichloro-2-propyl) phosphate | BDCIPP | 72236-72-7 | 316.9>35 | -30 | MSM2_NEG | 1.74 | |

HPLC method

Two separate LC columns – Ultra AQ C18; Betasil C18 2 mass spec methods.

An example total ion chromatogram (TIC; A) and extracted ion chromatograms (B–F) of 43 target compounds at concentration of 10 ng/mL measured in method 1 under negative mode (M1_NEG).

For the sake of distinction individual compounds, ion chromatograms were extracted and divided into five fractions (i.e., F1-F5) depending on their retention times and signal intensities. Peak numbers correspond to compounds in Table 1

50 picogram standard



Retention time (min)

Further details of additional peaks and chromatograms can be found in: JCA 1646 (2021), 462146.

Extraction method

Recoveries of seven phenolic compounds certified in standard reference material 3672 (SRM 3672) with different enzymatic deconjugation conditions including enzyme type (A), enzyme amount (B), buffer pH (C), and incubation time (D).





Multi-class analytical method capable to capturing 121 analytes in a single extraction

Sample Preparation

Enzymatic hydrolysis

0.5 mL of urine 2.5 ng each of IS 20 μL of ALS enzyme 0.5 mL of 1 M NH₄Ac buffer (pH 5.5)



Solid Phase Extraction

Agilent Bond Elut C18 (60 mg, 3 mL)



UPLC-MS/MS (API 5500+)

45

compounds

(mostly PMs)

1st injection:

MS/MS mode: ESI-negative Column: Ultra AQ C18 column (3 μ m, 100 \times 2.1 mm², Restek) MA: 0.1% v/v HAc in H₂O MB: 0.1% v/v HAc in MeOH Injection volume: 5.0 μ l Flow rate: 0.38 mL/min

2nd injection:

MS/MS mode: ESI-negative & positiveColumn: BetaSil™ C18 column(5 μm, 100 × 2.1 mm², TFS)MA: H₂OMB: ACN45 EPs (-ve)Injection volume: 5.0 μlFlow rate: 0.35 mL/min



Contents lists available at ScienceDirect

Journal of Chromatography A

journal homepage: www.elsevier.com/locate/chroma



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>95% analytes recovery 80-120% (accuracy); Variances : 0.4-11% (RSD; precision); LOD : <0.1 ng/mL for 101 analytes, 0.1-1 ng/mL for 18 analytes (sensitivity) Method requires only 0.5 mL urine Time and Cost reduced by 1/3

Aromatic amines

- A method was developed for the analysis of 44 aromatic amine in urine (manuscript submitted for publication)
- Many are known carcinogens
- Tattoos, hair dyes, printing inks, textile dyes
- Tobacco smoke
- Used in the production of polyurethane, rubber, pesticides, and pharmaceuticals



Biomonitoring Hydrolysis LLE **Isotopic dilution LC-MS/MS** > 10N NaOH (50 μL) 1.3e6 1.3e6 | B) With HCI 1.3e6 | 95 °C, 15h Shaking Centrifuge 656 686 556 586 486 356 356 356 256 256 216 0 **Evaporation** 1.545 Reconstitution Urine Time mir

A Liquid Chromatography –Tandem Mass Spectrometry Method for the Analysis of 44 Primary Aromatic Amines in Human Urine

Sridhar Chinthakindi and Kurunthachalam Kannan*

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Submitted to: Journal of Chromatography B





on Child Health Outcomes

A program supported by the NIH

Assessing exposures to novel chemicals among pregnant women in ECHO: a pilot to inform studies of associations with child health outcomes

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Tracey Woodruff, PhD, MPH

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Pilot study to measure novel chemicals among 171 pregnant women from 9 ECHO cohorts

| Cohort | Location | Enrollment |
|--|----------|--------------|
| Chemicals in our Bodies (CIOB) | CA | 2014-present |
| MARBLES | CA | 2006-present |
| MADRES | CA | 2016-present |
| Illinois Kids Development Study (IKIDS) | IL | 2013-present |
| Atlanta ECHO Cohort of Emory | GA | 2014-present |
| UPSIDE | NY | 2016-present |
| Fair Start | NY | 2013-present |
| New Hampshire Birth Cohort Study (NHBCS) | NH | 2009-present |
| ECHO in Puerto Rico (PROTECT) | PR | 2011-present |



Includes women from across the U.S. to capture geographic, temporal, and sociodemographic diversity

Next steps

Characterize exposure patterns

Compare concentrations by geographic location, calendar year, demographic variables, and urine sample collection characteristics

Determine correlations among chemicals





Full-scale study of prenatal novel chemical exposures and pre-, peri-, and postnatal outcomes



(pregnancy and birth)

Quantify novel chemical exposures for 6,330 pregnant women from 21 ECHO cohorts using the HHEAR assay

Investigate associations with perinatal outcomes: low birth weight, preterm birth, small for gestational age

Conduct a substudy with repeated samples during pregnancy to understand within-person variability

Leverage biomonitoring resource to study all priority child health outcomes in ECHO

ECHO's Mission To enhance the health of children for generations to come

PRE-, PERI-, ADD POSTINATAL (pregnancy and birth)
PRE-, PERI-, DUPER AND LOWER AIRWAY (breathing)
DESITY (breathing)
DESITY

Thank you



ECHO Environmental influences

on Child Health Outcomes

A program supported by the NIH