



ARE WE THREATENING OUR FERTILITY, INTELLIGENCE,
내분비계 장애물질의 위험과 극복
AND SURVIVAL?—A SCIENTIFIC DETECTIVE STORY

: 대체물질 개발의 중요성

OUR STOLEN FUTURE

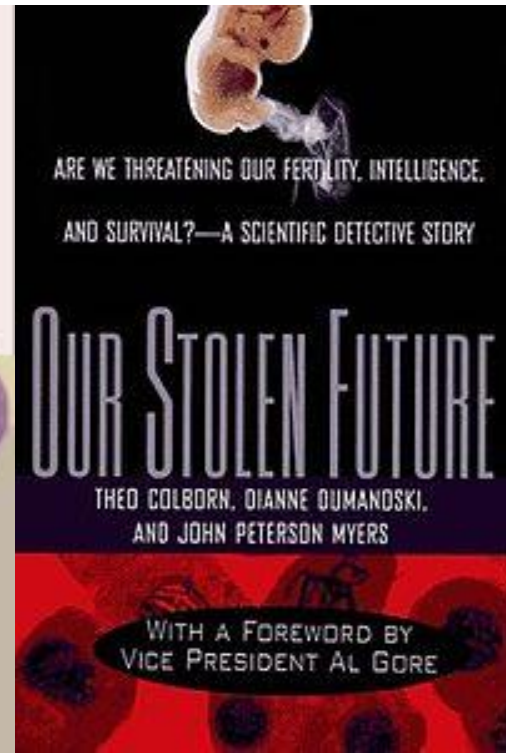
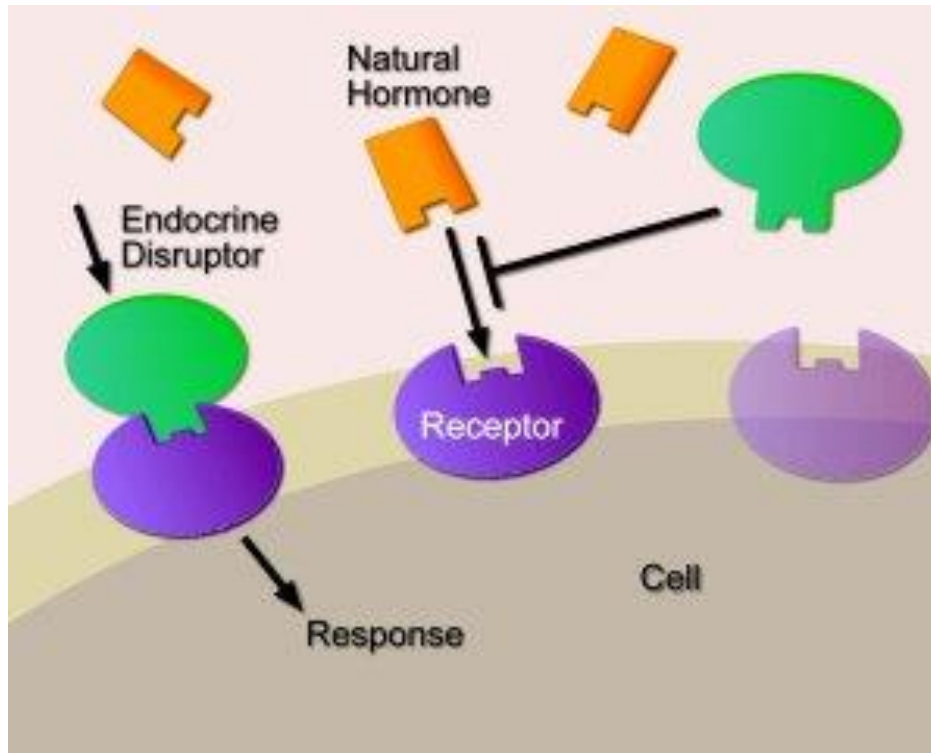
계 명 찬
한양대학교 생명과학과

THEO COLBORN, DIANNE DUMANDSKI,
AND JOHN PETERSON MYERS

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내분비계 장애물질 (Endocrine disruptor)



대표적인 내분비계 장애물질 Phthalate, BPA, Nonylphenol

- Phthalate, BPA, Nonylphenol은 대표적인 내분비계 장애물질(Endocrine disruptors)
- 90년대까지 규제 없이 합성도료, 플라스틱 원료, 배관, 통조림의 코팅용제로 사용
- 1996년 미국의 테오콜본의 『Our stolen future』의 출판 이후 관심 증가
- 그 유해성을 뒷받침 해주는 연구결과가 잇따라 발표됨
- 우리나라를 포함 미국, 유럽, 일본 등 세계 각국에서 사용을 제한하기 시작
- 다양한 대체물질들이 개발되어 쓰이고 있거나 개발 중임



Phthalate



Phthalate

| Name | 약어 | CAS No. | 관련규제 |
|---|------------------------------|-------------------|--|
| Dimethyl phthalate | DMP ^{*note4} | 131-11-3 | |
| Diethyl phthalate | DEP ^{*note1} | 84-66-2 | |
| Diallyl phthalate | DAP | 131-17-9 | |
| Di-n-propyl phthalate | DPP | 131-16-8 | |
| Di-n-butyl phthalate | DBP^{*note2} | 84-74-2 | REACH(SVHC 포함), CPSIA(미국 소비자제품 안전개선법), RoHS Directive 개정(안) |
| Diisobutyl phthalate | DIBP ^{*note3} | 84-69-5 | |
| Butyl cyclohexyl phthalate | BCP | 84-64-0 | |
| Di-n-pentyl phthalate | DNPP | 131-18-0 | |
| Dicyclohexyl phthalate | DCP | 84-61-7 | |
| Butyl benzyl phthalate | BBP | 85-68-7 | REACH(SVHC 포함), CPSIA RoHS Directive 개정(안) |
| Di-n-hexyl phthalate | DNHP | 84-75-3 | |
| Diisohexyl phthalate | DIHxP ^{*note5} | 146-50-9 | |
| Diisoheptyl phthalate | DIHpP | 41451-28-9 | |
| Butyl decyl phthalate | BDP | 89-19-0 | |
| Di(2-ethylhexyl) phthalate | DEHP | 117-81-7 | REACH(SVHC 포함), CPSIA RoHS Directive 개정(안) |
| Di(n-octyl) phthalate | DNOP^{*note6} | 117-84-0 | CPSIA 잠재규정 |
| Diisooctyl phthalate | DIOP | 27554-26-3 | |
| n-Octyl n-decyl phthalate | ODP | 119-07-3 | |
| Disononyl phthalate | DINP^{*note6} | 28553-12-0 | CPSIA 잠재규정 |
| Disodecyl phthalate | DIDP^{*note6} | 26761-40-0 | CPSIA 잠재규정 |
| Diundecyl phthalate | DUP | 3648-20-2 | |
| Diisoundecyl phthalate | DIUP | 85507-79-5 | |
| Ditridecyl phthalate | DTDP | 119-06-2 | |
| Diisotridecyl phthalate | DIUP | 68515-47-9 | |
| Polyethylene terephthalate | PETE | 25038-59-9 | 프탈레이트 용어가 쓰이지만 실제 화학구조체가 다름. 프탈레이트가 아님. |

프탈레이트의 위험성

한국경제TV

건강을 위해 버려야 할 것, 방향제도? 무심코 방치했다간..

기사입력 2015-03-20 13:35 기사원문  0 >



두 번째는 방향제인데 일부 제품에는 향기가 오래 머물도록 만드는 프탈레이트가 들어있다. 프탈레이트는 내분비계 장애를 일으키는 인체에 유해한 환경호르몬으로 알려졌다.

일부 업체에서는 방향제 안에 프탈레이트를 첨가하지 않았다고 밝혔지만, 아직도 많은 제품 속에는 이 물질이 들어있다고 전해졌다.

*한국경제 2015.03.20

美 컬럼비아대 "IQ 6~7 차이, 학업성취도에 영향 미쳐"

환경호르몬 '프탈레이트'가 IQ 6~7 떨어뜨려

| 입력 2014년 12월 15일 11:27 | 최종편집 2014년 12월 15일 18:00



립스틱, 매니큐어와 헤어스프레이, 비닐장판(PVC 바닥재) 등에 들어 있는 환경호르몬 물질 '프탈레이트'. 최근 이 프탈레이트가 아이의 지능지수(IQ)를 떨어뜨릴 수 있다는 연구 결과가 나왔다. IQ는 기억력과 작업처리 속도와 관련 있다고 알려진 지표다.

미국 컬럼비아대 연구팀은 뉴욕 시에 거주하는 임신부 328명의 소변 속에 들어있는 프탈레이트 4종의 대사체를 조사했다. 그리고 이들이 낳은 아이가 7세가 됐을 때 IQ를 측정한 결과 부틸프탈레이트와 이소부틸프탈레이트가 높은 엄마에게서 태어난 아이의 IQ가 다른 아이들보다 낮다는 사실을 확인했다.



▲ Stockphoto 제공

*동아사이언스 2014.12.15

프탈레이트의 위험성

Effect of DEHP on Human Health

Toxicity

- The [acute toxicity](#) of DEHP is low in animal models: 30 g/kg in rats (oral) and 24 g/kg in rabbits (dermal). Concerns instead focus on its potential as an [endocrine disruptor](#).

Development

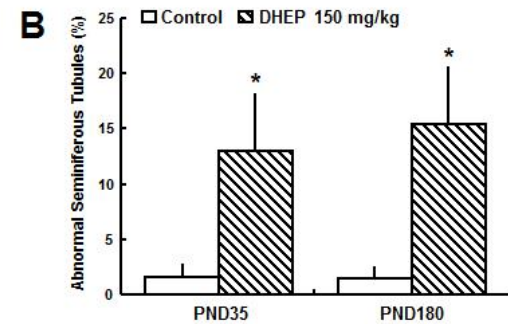
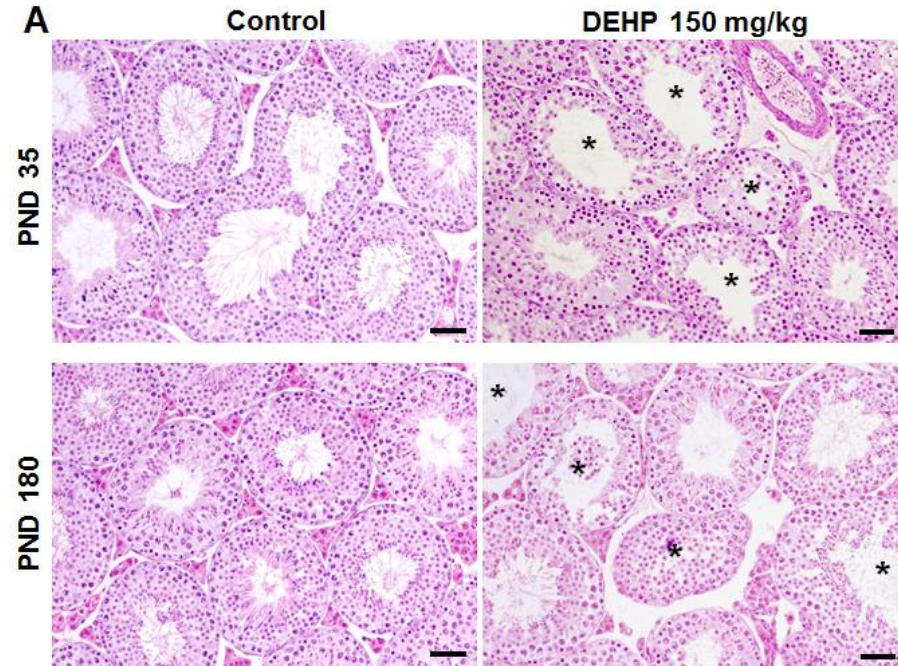
- Approximately 25% of US women have phthalate levels similar to those in the study. However, the study author cautioned that replication of these results are needed to strengthen any links between phthalates and adverse health outcomes.

Obesity

- A study on [CDC](#) data, "revealed that American men with abdominal [obesity](#) or [insulin resistance](#) (a precursor to [diabetes](#)) were more likely to have high levels of [DEHP and [DBP](#)] metabolites in their urine than men without those problems.

Cardiotoxicity

- A clinically relevant dose and duration of exposure to DEHP has been shown to have a significant impact on the behavior of [cardiac](#) cells in culture.



프탈레이트의 유해성 연구동향

Research | Children's Health

Relationship between Environmental Phthalate Exposure and the Intelligence of School-Age Children

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국민일보

플라스틱 가소제 '프탈레이트' 어린이 두뇌발달 약 영향

23면 3단 | 기사일력 2014-12-02 02:52 기사원문 0 >

2014 Nov Association between phthalates and externalizing behaviors and cortical thickness in children with attention deficit hyperactivity disorder.

Psychol Med

Psychol Med 2014 Nov 12:1-12. Epub 2014 Nov 12.

S Park, J-M Lee, J-W Kim, J-H Cheong, H-J Yun, Y-C Hong, Y Kim, D-H Han, H-J Yoo, M-S Shin, S-C Cho, B-N Kim



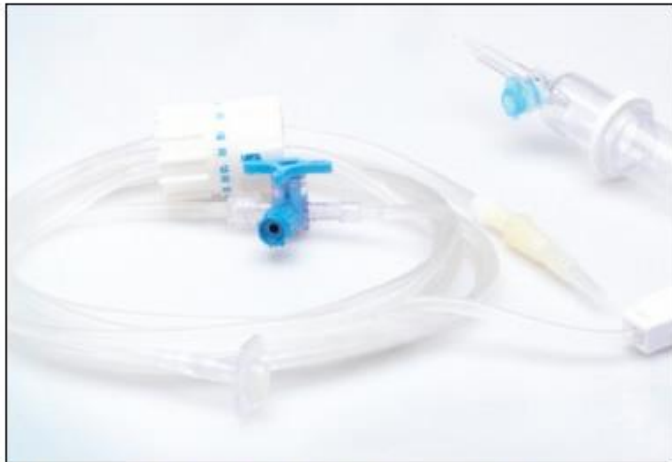
Background. Previous studies have implicated the relationship between environmental phthalate exposure and attention deficit hyperactivity disorder (ADHD) symptoms of childhood, but no studies have been conducted in children who have a confirmed diagnosis of ADHD obtained through meticulous diagnostic testing. We aimed to determine whether phthalate metabolites in urine would be higher in children with ADHD than in those without ADHD and would correlate with symptom severity and cortical thickness in ADHD children. **Method.** A cross-sectional examination of urine phthalate metabolite concentrations was performed; scores for ADHD symptoms, externalizing problems, and continuous performance tests were obtained from 180 children with ADHD, and brain-imaging data were obtained from 115 participants. For the control group, children without ADHD (N = 438) were recruited. Correlations between phthalate metabolite concentrations and clinical measures and brain cortical thickness were investigated. **Results.** Concentrations of phthalate metabolites, particularly the di(2-ethylhexyl) phthalate (DEHP) metabolite, were significantly higher in boys with ADHD than in boys without ADHD. Concentrations of the di-n-butyl phthalate (DBP) metabolite were significantly higher in the combined or hyperactive-impulsive subtypes compared to the inattentive subtype, and the metabolite was positively correlated with the severity of externalizing symptoms. Concentrations of the DEHP metabolite were negatively correlated with cortical thickness in the right middle and superior temporal gyri. **Conclusions.** The results of this study suggest an association between phthalate concentrations and both the diagnosis and symptom severity of ADHD. Imaging findings suggest a negative impact of phthalates on regional cortical maturation in children with ADHD.

Phthalate 대체재 필요성 대두

노컷뉴스

프탈레이트, 장난감에서도 빼는데 임신부에 사용?

기사입력 2012-01-05 15:11 기사원문 0 >



▲ 프탈레이트는 대표적인 환경호르몬으로 우리 몸 속 내분비계에 장애를 유발하는 것으로 알려져 있다. (자료 메디라인엑티브코리아)

- Chemical Alternatives to Phthalates
- Alternative Plastics that Do Not Require Phthalates
 - Petroleum-based
 - Bio-based

수액제 이어 의료기기도 프탈레이트류 '퇴출'

정부, 산·학·연 협의체 구성...전문가들 "인체 치명적, 대체재 사용해야"

2015.03.04 07:04 입력

수액세트에 사용돼 온 프탈레이트(DEHP, DBP, BBP)가 암 유발 및 생식기 이상 등의 문제가 드러나면서 오는 7월부터 전면 사용이 금지된 가운데 의료기기 분야에서도 프탈레이트 퇴출 바람이 거센 모습이다.

환경호르몬 일종인 프탈레이트는 인체 내분비계 교란을 가져오는 것으로 알려져 의료제품은 물론 대다수 생활용품에서 사용 축소가 진행 중이다.

정부는 프탈레이트의 의료기기 내 사용 금지를 위해 협의체를 구성하는 등 적극적인 퇴출 방안을 논의 중인 것으로 알려졌다.

특히 쟁점으로 부상한 것은 수액세트와 같이 의료기기에 DEHP, DBP, BBP 3종에 대한 사용을 금지할 것인지 아니면 모든 프탈레이트류로 금지 범위를 확대할 것인지 여부다.

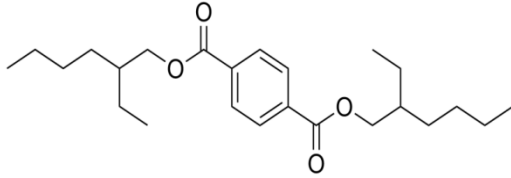
또 프탈레이트 퇴출에 객관적 근거를 마련중인 정부는 물론 의료계 전문가들은 의료기기에 **서 프탈레이트류 전부에 대한 사용을 전면 금지해야한다고 지적하고 있다.**

프탈레이트 제품은 올 1월부터 수은을 함유한 의료기기, 수액세트와 함께 제조·수입 판매가 금지됐다.

Phthalate 대체재

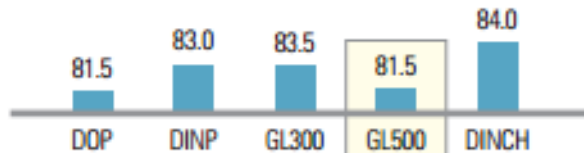
| 대체재 | 특장점 | 단점 |
|--|--|--|
| <p>BTHC (Trihexyl o-butyryl citrate)</p> | <p>RBC(적혈구) container로 개발. 독성이 나타나지 않음. DEHP와 유사하거나 뛰어넘는 능력임. 내냉성을 가지면서 RBC를 4도에서 35일동안 유지시켜줌.</p> | <p>냄새가 날수 있으며가격이 비쌌. 증기멸균이 불가능함 (의료용 제품에 적용 힘듬).</p> |
| <p>ATBC (Acetyl Tri-n-Butyl Citrate)</p> | <p>BTHC와 유사 미국에서 주요 이용되는 대체 가소제중 하나</p> | <p>효율이 낮아 동일한 효과를 내기 위해 보다 많은 양이 필요.</p> |
| <p>DINCH (diisononyl-cyclohexane-1,2-dicarboxylate)</p> | <p>구조와 기능적으로 DEHP와 유사하지만 DEHP단점은 줄어든 조건. FDA 승인 받음</p> | <p>독성이 전혀 없는 것은 아니며 내분비계장애 유발이 보고됨</p> |
| <p>DEHA (di-(2-ethylhexyl)adipate)</p> | <p>DEHP와 유사</p> | <p>특별한 장점이 없으며 독성 역시 DEHP와 유사해 거의 쓰이지 않음</p> |
| <p>TOTM (Trioctyltrimellitat)</p> | <p>DEHP와 유사한 특성 독성을 나타내지 않음 혈액팩에 이용하기 용이 수생독성 없음 가장 많이 쓰이는 프탈레이트 대체 가소제 중 하나</p> | <p>DEHP에 비해 효율이 낮아 동일효과를 위해 보다 많은 양이 필요</p> |

Phthalate 대체재: Dioctylterephthalate(DOTP)

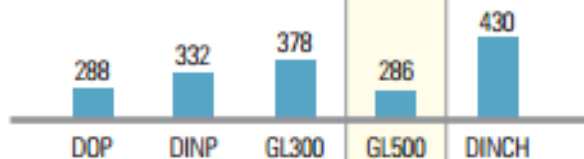


- 프탈레이트류 물질에서 알려진 각종 독성 영향과 내분비계장애를 일으키지 않으면서 그 기능이 거의 유사(80~90% 효율)
- 대표적 프탈레이트인 DEHP와 DINP를 대체할 수 있는 친환경 대체재

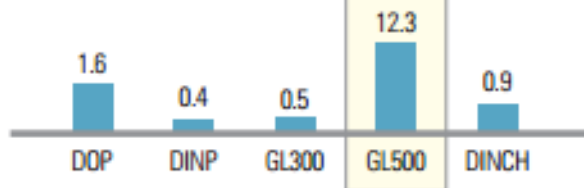
• 경도(가소화효율)



• 가소제 흡수속도(sec)



• 가열감량(%)



- LG화학에서 GL300과 GL500이라는 제품명으로 생산 및 판매
- 환경규제가 강화됨에 따라 사용 빈도가 증가
- 기존의 프탈레이트 가소제보다 가격 경쟁력이 떨어짐

Phthalate 대체재: Oligomeric Isosorbide Esters

Oligomeric Isosorbide Esters as Alternative Renewable Resource Plasticizers for PVC

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Published online 1 September 2010 in Wiley Online Library (wileyonlinelibrary.com).

ABSTRACT: Oligo(isosorbide adipate) (OSA), oligo(isosorbide suberate) (OSS), and isosorbide dihexanoate (SDH) were synthesized and evaluated as renewable resource alternatives to traditional phthalate plasticizers. The structure of the synthesized oligomers was confirmed by nuclear magnetic resonance spectroscopy (^1H - and ^{13}C -NMR), and molecular weight was determined by size exclusion chromatograph. The plasticizers were blended with poly(vinyl chloride) (PVC), and the miscibility and properties of the blends were evaluated by differential scanning calorimetry, fourier transform infrared spectroscopy, tensile testing, and thermogravimetry. Especially the

blends plasticized with SDH had almost identical properties with PVC/diisooctyl phthalate (DIOP) blends. The blends containing OSA and OSS plasticizers, based on dicarboxylic acids, had somewhat lower strain at break but higher stress at break and better thermal stability compared to the PVC/DIOP or PVC/SDH blends. All the synthesized isosorbide plasticizers showed potential as alternative PVC plasticizers. © 2010 Wiley Periodicals, Inc. *J Appl Polym Sci* 119: 2400–2407, 2011

Key words: poly(vinyl chloride); PVC; renewable resources; blends; polyesters; isosorbide

Phthalate 대체재에 대한 우려

TECHNICAL BRIEFING

PHthalATES AND THEIR ALTERNATIVES: HEALTH AND ENVIRONMENTAL CONCERNS



JANUARY 2011



Lowell Center for Sustainable Production

UNIVERSITY OF MASSACHUSETTS LOWELL

The Lowell Center for Sustainable Production at the University of Massachusetts Lowell helps to build healthy work environments, thriving communities, and viable businesses that support a more sustainable world.

Alternative plasticizers

| Alternative | Function/Product | Human Health Concerns | Environmental Concerns |
|---|--|--|---|
| ATBC: Acetyl tributyl citrate | <ul style="list-style-type: none"> Primarily used as a plasticizer in cosmetic products, toys, vinyl, adhesives, medical devices, pharmaceutical tablet coatings, food packaging, flavoring substance in foods, printing inks and plastics in concrete. Also used as a surface lubricant in the manufacture of metallic articles that contact food [14, 15, 17, 19, 21]. | <ul style="list-style-type: none"> Intravenous exposure affects the central nervous system and blood in laboratory animals. May have moderate irritation effects on eyes and increase liver weights [21]. Studies show that it inhibits the proliferation of Lymph node T cells [16]. Exhibits fire and explosive hazard in the presence of strong oxidizers and nitrates [14]. | <ul style="list-style-type: none"> Can bioaccumulate and is inherently biodegradable (in an inherent biodegradation test, 80 percent was degraded). However, in a non-standard test aerobic degradation was slow and no data is available on anaerobic degradation [21]. |
| DINCH: DI-Isononyl-cyclohexane-1, 2-dicarboxylate | <ul style="list-style-type: none"> Primarily used as a plasticizer in PVC medical devices (blood tubes or packaging for nutrient solutions), toys, food packaging, cosmetics products, shoes, exercise mats and cushions, textile coatings, printing inks [17]. | <ul style="list-style-type: none"> Acute toxicity effect is low. However, an increase in testes weight, liver weight, thyroid weight, serum gamma-glutamyl transferase and thyroid-stimulating hormone was observed in laboratory animals after repeated exposure. Blood and transitional epithelium cells in urine was also observed [22, 40]. | <ul style="list-style-type: none"> No data found regarding effects of environmental exposures. |

These are being substituted in products that traditionally use phthalates, such as toys, childcare articles and medical devices

Most of these alternative plasticizers are not well studied with regard to their potential effects on human health and the environment

Petroleum-based plastics

| Plastic | Application/Product | Human Health Concerns | Environmental Concerns |
|---------------------|---|---|---|
| PU: Polyurethane | <ul style="list-style-type: none">Extensively used for applications where PVC or rubber are used [6]. Used in foam toys, fabrics (in furniture garments and upholstery), wheels, insulators in kitchen appliances, decoration moldings (door frames, windows, columns, medallions), and in construction as sealants.Also used as adhesive for woods and in varnishes [49]. | <ul style="list-style-type: none">Combustible. Produces highly toxic hydrogen cyanide in fires.Can cause mechanical irritation to the eyes and lungs in dust form.Exposure to high levels of methylene diphenyl isocyanate and toluene diisocyanate (substances used to produce PU) causes severe lung and eye damage, severe irritation to mucous membranes, euphoria, ataxia, mental aberrations, asthmatic attacks, chest tightness, coughing, breathlessness, inflammation of the bronchi, and noncardiogenic pulmonary edema [49].Toluene diisocyanate is classified as a possible human carcinogen by IARC [52]. | <ul style="list-style-type: none">Methylene diphenyl isocyanate and toluene diisocyanate degrade rapidly in the environment.No effects have been observed in landfill disposal or after incineration [49]. |

Although all plastics require the use of additives in processing to improve material properties, many types of plastic require fewer and less harmful additives than those required by PVC

Petroleum-based plastics are produced from non-renewable fossil fuel resources.

The production of these plastics poses a variety of health and environmental concerns.



Bio-based plastics

| Plastic/Source | Application/Product | Human Health Concerns | Environmental Concerns |
|--|---|--|---|
| Polylactic Acid (PLA)/corn, sugar beets, sugar cane, wheat, sweet potatoes or rice | <ul style="list-style-type: none"> Used for hard resin for food containers, film and fibers (apparel and carpeting applications, clothing). May replace thermo-plastics in many applications. Properties are similar to poly-ethylene terephthalate, polypropylene and polystyrene [57]. | <ul style="list-style-type: none"> Purification of lactic acid requires sulfuric acid. Uses tin octanoate as a catalyst in processing. Tin octanoate can cause neurotoxic and cytotoxic effects in animals. Organic tin compounds can cause irritation of the skin and lungs, and also masculinization of female or infertility in male aquatic animals. Emerging health concerns about tin residues in PLA used in medical applications. 1-octanol used as a polymerization initiator is volatile and combustible and can cause irritation to tissues. E-coprolactone used to improve properties causes skin irritation and may cause respiratory tract irritation [57]. | <ul style="list-style-type: none"> Concerns about environmental impacts from use of bioengineered microorganisms in crop production. Can be completely recycled to lactic acid (but required infrastructure for recycling does not exist). Will compost at temperatures above 60 °C (must hydrolyze first and needs commercial composting infrastructure which it is not widely available) and can be safely incinerated [57]. 1-octanol used as a polymerization initiator is toxic to aquatic organisms |

Alternatives to petroleum-based plastics.


Many of these plastics are currently under development for a wide range of commercial applications.

TOTM (Trioctyltrimellitate)

Scientific Committee on Emerging and Newly-Identified Health Risks
SCENIHR

OPINION ON
THE SAFETY OF MEDICAL DEVICES CONTAINING DEHP-
PLASTICIZED PVC OR OTHER PLASTICIZERS ON NEONATES AND
OTHER GROUPS POSSIBLY AT RISK

 Scientific Committees
+ on consumer products
+ on emerging and newly identified health risks
+ on health and environmental risks

Adopted after public consultation by the SCENIHR
during the 22nd Plenary of 6 February 2008



Medical device and other plastic products

The production volume in Japan is about 20.000 tonnes/year and there are 5 manufacturers in Japan. Estimated global production is 40,000-100,000 tonnes/year. **TOTM is mainly used as a plasticizer for PVC electrical cables and wire. In medical devices TOTM is used as a PVC plasticizer in various infusion equipments. Trimellitate plasticizers are the alternative for phthalate plasticizers when high temperature applications and low volatility are of importance. The end products include oil resistance products, gasoline hoses, rain shoes, gasketing, and vehicle engine wires.** TOTM has unique low leaching properties and extraction resistance properties that are required for dishwasher gaskets, medical tubing and photograph storage.

TOTM사용 현황

친환경 가소제

환경호르몬 논란 속 DOP 대체 가속화

가소제는 에스터화(Esterification) 반응을 통해 얻어지는 유기에스터 화합물로 레자, Sheet, PVC(Polyvinyl Chloride) 필름, 전선 등 열가소성 플라스틱에 첨가돼 고온 성형가공을 용이하게 하며 유연성, 내열성, 내한성, 전기적 특성 등을 강화하는데 사용된다.

국내 가소제 생산능력은 79만톤으로 애경유화와 LG화학이 DOP(Dioctyl Phthalate) 기준 각각 35만톤과 24만톤의 생산타인을 보유해 74%의 점유율을 나타내고 있다. 2003년 KP케미칼 가소제 사업부를 인수한 동양제철화학이 10만톤, 한화석유화학 8만5000톤, 애경공업 1만톤, 송원산업 5000톤으로 나머지 26%를 차지하고 있다.

가소제 생산은 2002년 63만776톤, 2003년 63만5223톤에서 2004년 65만3399톤으로 2.9% 증가했다. 내수부진으로 수입은 계속 줄어 2002년 6415톤, 2003년 6129톤, 2004년 4333톤으로 급감했다.

반면, 국내판매는 다소 늘어 2002년 20만1211톤, 2003년 20만4015톤, 2004년 22만9082톤을 기록했고 수출은 2002년 28만1331톤, 2003년 28만8570톤, 2004년 27만433톤으로 다소 줄었다.

국내 가소제 공급현황

| 구분 | 2002 | 2003 | 2004 | 증감률 |
|------|---------|---------|---------|-------|
| 생산능력 | 785 000 | 790 000 | 790 000 | 0.0 |
| 생산 | 630 776 | 635 223 | 653 399 | 2.9 |
| 수입 | 6 415 | 6 129 | 4 333 | ▽29.3 |
| 공급계 | 637 191 | 641 352 | 657 732 | 2.6 |
| 국내판매 | 201 211 | 204 015 | 229 082 | 12.3 |
| 수출 | 281 331 | 288 570 | 270 433 | ▽6.3 |
| 판매계 | 482 542 | 492 585 | 499 515 | 1.4 |
| 국내수요 | 356 000 | 355 000 | 397 600 | 12.0 |
| 재고 | 28 337 | 16 515 | 19 679 | 19.2 |
| 가동률 | 80.3 | 80.4 | 82.7 | - |

자료) 통계청, KOTIS

국내 가소제 생산능력

| 회사명 | 생산능력 | 점유율 | 생산제품 |
|--------|---------|-----|---------------------------------|
| 애경유화 | 350 000 | 44 | DOP, DINP, DIDP, DBP, DOA, TOTM |
| LG화학 | 240 000 | 30 | DOP, DINP, DIDP, DBP, DOA, TOTM |
| 동양제철화학 | 100 000 | 13 | DOP, DINP, DIDP |
| 한화석유화학 | 85 000 | 11 | DOP, DINP, DIDP, DOA |
| 애경공업 | 10 000 | 1 | DOP, DOA, TOTM |
| 송원산업 | 5 000 | | DOP, TOTM |
| 합계 | 790 000 | 100 | |

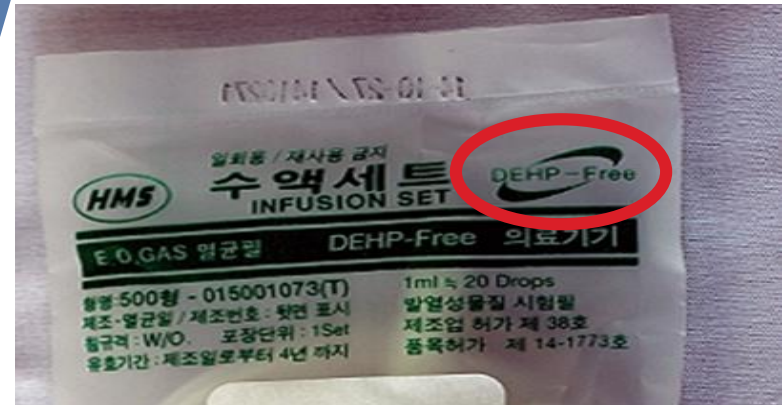
자료) 통계청, KOTIS

국내 가소제 생산능력

(단위: M/T, %)

| 회사명 | 생산능력 | 점유율 | 생산제품 |
|--------|---------|-----|---------------------------------|
| 애경유화 | 350 000 | 44 | DOP, DINP, DIDP, DBP, DOA, TOTM |
| LG화학 | 240 000 | 30 | DOP, DINP, DIDP, DBP, DOA, TOTM |
| 동양제철화학 | 100 000 | 13 | DOP, DINP, DIDP |
| 한화석유화학 | 85 000 | 11 | DOP, DINP, DIDP, DOA |
| 애경공업 | 10 000 | 1 | DOP, DOA, TOTM |
| 송원산업 | 5 000 | | DOP, TOTM |
| 합계 | 790 000 | 100 | |

자료) 통계청, KOTIS



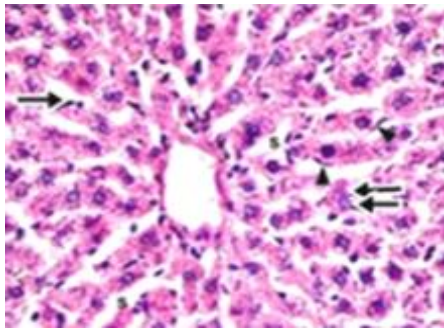
국내에서 TOTM을 생산하고 있으며, TOTM이 쓰인 의료용품 역시 생산되고 있음
구체적인 규제는 협의 중.

TOTM의 안전성

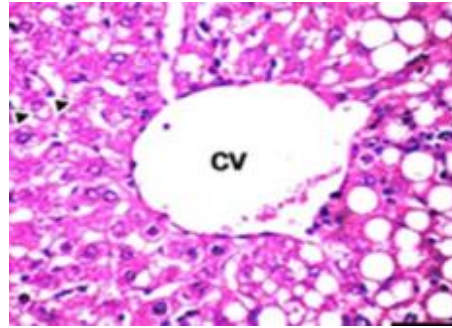
Research Article

Open Access

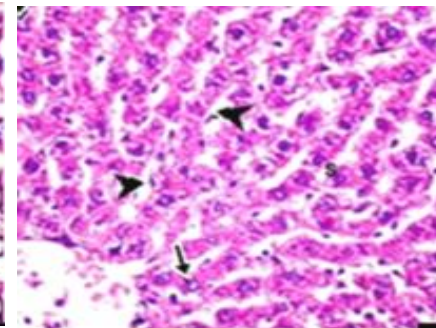
Effects of Exposure to Plasticizers Di-(2-Ethylhexyl) Phthalate and Trioctyltrimellitate on the Histological Structure of Adult Male Albino Rats' Liver



Control



DEHP



TOTM

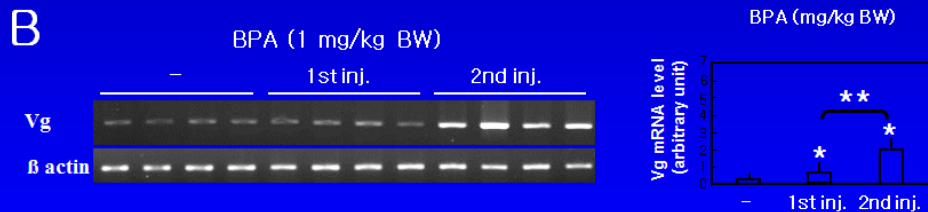
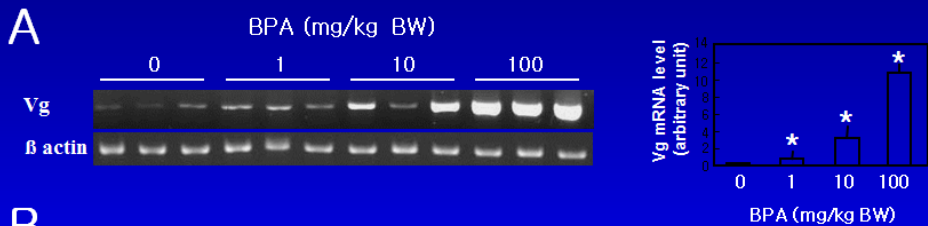
Bisphenol A

가장 대표적인 에스트로젠성 내분비계장애물질

투명플라스틱, 폴리카보네이트 생산에 다량 필요



Effect of bisphenol A on the expression of Vg in male liver



BPA-Free

- BPA의 유해성이 보고된 후 다른 대체물질들이 사용되기 시작
- 같은 비스페놀계열 물질인 '**BPS**'(감열지,플라스틱 제품)와 '**BPF**'(코팅제)
- 이들 물질은 그 유해성에 대해 알려지지 않았을 뿐 구조적으로 BPA와 유사
- BPS와 BPF역시 내분비계장애를 유발



Non-Bisphenol 계 BPA 대체재

Biopolymer (옥수수 유래 isosorbide)



식물유래 화합물(biopolymer)

안전한 BPA대체재

제조 단가가 높음

함량이 늘어날 경우 물성이 떨어짐

tritan (copolyester)



현재가장 많이 사용되는 BPA대체

SK Chemical에서 tritan과 같은 copolyester 제품

ECOZEN, SKYGREEN, SKYPET 생산

내분비계장애를 유발하지 않는 것으로 알려짐

2011년 tritan을 이용한 제품 역시 에스트로겐활성을 보인다고 보고

Copolyester

Communication



Received: 25 March 2011

Accepted: 16 April 2011

Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/pi.3122

Copolyesters as non-toxic plasticizers

Jiawen Zhou and Helmut Ritter*

Abstract

Plasticized polymer materials have taken an enormous role in our everyday life. Most of the common plasticizers are aromatics, esters of phthalic acid. Since they are not chemically bonded to the polymer matrix, they can be released from material while being used. The concerns raised about toxicity led to a large demand for producing biodegradable and non-toxic plasticizers. We investigated aliphatic copolyesters synthesized via ring opening polymerization of lactones as plasticizers for poly(vinyl chloride). The material properties of the formulations, such as glass transition temperature and mechanical performance, were studied.

© 2011 Society of Chemical Industry

Keywords: lactone; polyester; plasticizer; poly(vinyl chloride)

-Polymer International 2011. 07. 14

Tritan (Copolyester)

투명한 유리와 깨지지 않는 플라스틱의 장점을 결합한 친환경 재질입니다. 환경호르몬인 비스페놀-A(BPA)가 검출되지 않아 안심하고 사용할 수 있습니다.

특징

- ① 안전성: 인체에 유해한 환경호르몬이 나오지 않음
- ② 내구성: 충격에 강하기 때문에 흠집이 잘 나지 않고, 식기세척기 사용이 가능
- ③ 내열성: 열에도 쉽게 변형되지 않아 열탕 소독과 전자레인지 데우기 가능
- ④ 활용성: 사용 후, 100% 재활용이 가능



식기에 트라이탄 소재가 사용 증가

요거프레스, 트라이탄 소재 활용한 '요프보틀' 출시

2014-07-03 16:37

[뉴스핌=이수호 기자] 요거프레스는 트라이탄 소재를 적용한 투명 텀블러 '요프보틀'을 출시한다고 3일 밝혔다.

2000개 한정으로 제작된 요프보틀은 500mL의 용량이며 가격은 1만5000원이다. 휴게소 및 일부 매장을 제외한 전국 요거프레스 매장에서 구입할 수 있다.



Tritan: Result of binding assay

The assay uses a sensitive polarographic detection system based on a fluorescent labeled ligand (Fluormone™) to form a receptor-ligand complex with a subsequent high polarization value that is added to varying concentrations of test compounds.

A reduction in the polarization signal will occur if a test compound has the ability to displace the Fluormone™ ligand from the complex and to competitively bind to the receptor. The assay provides data on the absolute and relative binding affinity and potency of test compounds.

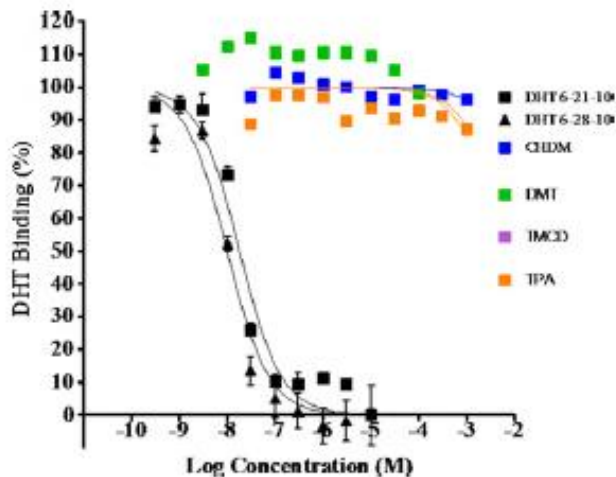


Fig. 1. *In vitro* Androgen Receptor Binding Assay.

3.2. *In vitro* Androgen Receptor Binding Assay

None of the test articles (TMCD, CHDM, DMT, and its metabolite, TPA) resulted in a significant displacement of the ligand from the receptor. Thus, all four compounds tested were classified as non-binders for the AR (Fig. 1).

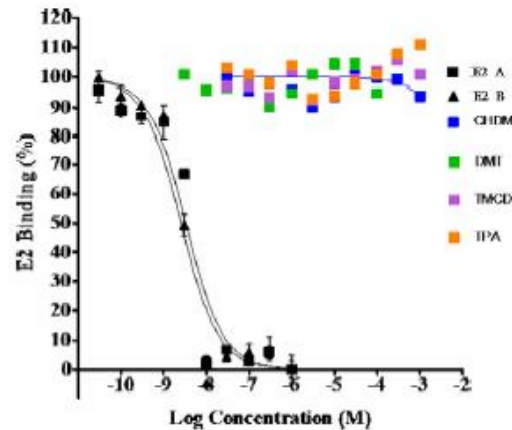


Fig. 2. *In vitro* Estrogen Receptor Alpha Binding Assay.

3.3. *In vitro* Estrogen Receptor Binding Assay

None of the test articles (TMCD, CHDM, or DMT and its metabolite TPA) resulted in a significant displacement of the ligand from the receptor. Thus, all four compounds tested were classified as non-binders for both the estrogen *alpha* and *beta* receptors (Figs. 2 and 3).

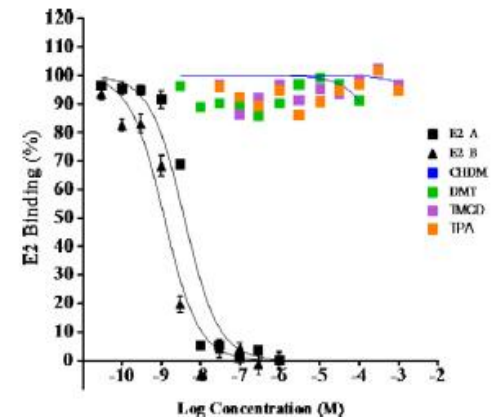


Fig. 3. *In vitro* Estrogen Receptor Beta Binding Assay (all test articles).

Tritan: Lack of endocrine activity

Lack of androgenicity and estrogenicity of the three monomers used in Eastman's Tritan™ copolyesters

Thomas G. Osimitz^{a,*}, Melanie L. Eldridge^b, Eddie Slotter^c, William Welsh^d, Ni Ai^d, Gary S. Sayler^{b,e}, FuMin Menn^b, Colleen Toole^f

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^bThe Center for Environmental Biotechnology, University of Tennessee, Knoxville, TN 37996, USA

^cWIL Research Laboratories LLC, 1407 George Road, Ashland, OH 44805-9281, USA

^dDept. of Pharmacology, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ 08854, USA

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Estrogenicity

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1,4-Cyclohexanedimethanol

2,2,4,4-Tetramethyl-1,3-cyclobutanediol

Monomer

ABSTRACT

Eastman Tritan™ copolyester, a novel plastic from Eastman is manufactured utilizing three monomers, di-methylterephthalate (DMT), 1,4-cyclohexanedimethanol (CHDM), and 2,2,4,4-tetramethyl-1,3-cyclobutanediol (TMCD) in various ratios. As with most any polymer, the monomers along with the high molecular weight oligomers, whose toxicity is most commonly represented by the monomers, make up the predominate amount of free chemicals available for leaching into the environment and/or foods. In light of the high level of public concern about the presence of endocrine (primarily estrogenic) activity ascribed to certain plastics and chemicals in the environment, Tritan's™ monomers were evaluated using QSAR for binding to the androgen receptor and estrogen receptors (*alpha* and *beta*) as well as a battery of *in vitro* and *in vivo* techniques to determine their potential androgenicity or estrogenicity. The findings were universally negative. When these data are coupled with other *in vivo* data developed to assess systemic toxicity and developmental and reproductive toxicity, the data clearly indicate that these monomers do not pose an androgenic or estrogenic risk to humans. Additional data presented also support such a conclusion for terephthalic acid (TPA). TPA is also a common polyester monomer and is the main mammalian metabolite formed from DMT.

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-Food and Chemical Toxicology 2012. 02. 17

Endocrine disruption by Tritan



New Review from TEDX: Common substitutes for bisphenol A (BPA) are hormonally active

New Third-Party Test Results Confirm Eastman Tritan Copolyester is Free of Bisphenol A and Estrogenic Activity

🕒 Thu, 05/13/2010 - 10:26am

👤 by Eastman

✉ [Get today's news and top headlines for chemical processing professionals - Sign up now!](#)

Rigorous material testing responds to marketplace demand for product safety and reliability

Kingsport, Tenn. — May 13, 2010 — Eastman Chemical Company today released test results that demonstrate Eastman Tritan™ copolyester is free from bisphenol A (BPA) and estrogenic activity (EA). Tests were conducted by various third-party research laboratories using well-recognized methods. The results of this research highlight Eastman's commitment to quality and dedication to providing reassurance to original equipment manufacturers (OEM), suppliers and the public that Tritan is free of endocrine disrupting chemicals (EDCs).

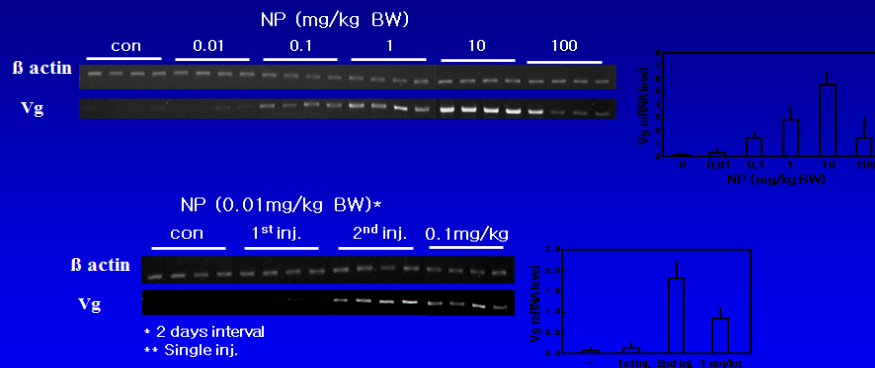
Eastman Tritan™ is a new-generation copolyester that provides a balance of properties to help manufacturers and designers respond to consumer demand for safe, reliable products that offer superior clarity, dishwasher durability, toughness and exceptional design potential.

Nonylphenol

- 계면활성제(detergent), 세제원료
- 도료 및 고무와 플라스틱 첨가제
- 수생동물에서 다양한 수준의 내분비계장애효과 유발
- 주방용 세제 및 식품첨가물로 사용 금지
- 세척제, 잉크바인더, 페인트용 제조·수입 및 사용금지 협의 중



Effect of nonylphenol on the expression of Vg in male liver



Skin pigmentation



Nonylphenol 대체재

미국 환경 보호청(EPA)에서 제안한 Nonylphenol 대체 detergent 8종

| 화학물질명 | 잔존량 | 위험분해 물질 | 급성 | 만성 수생 독성 | 분해물질 수생독성 | DfE 기준 계면활성 준수여부 |
|--|-----|------------|----|-------------|--------------|------------------------|
| C9-11 Alcohols, ethoxylated (6 EO) | VL | N | H | H | L | Y |
| C12-15 Alcohols, ethoxylated (9EO) | VL | N | VH | H | L | Y |
| Ethoxylated/propoxylated alcohols | L | N | M | M | L | Y |
| Alkyl polyglucose (APG) | VL | N | M | M | L | Y |
| Linear alkylbenzene sulfonates (LAS) | VL | N | H | H | L | Y |
| Alkyl sulfate esters (AS) [sodium lauryl sulfate] | VL | N | H | H | L | Y |
| Alkyl ether sulfates (AES) | L | N | H | H | L | Y |
| Sorbitan esters | L | N | H | H | L | Y |

VL = Very low hazard, L = Low hazard, M = Moderate hazard, H = High hazard, VH = Very high hazard, Y=Yes, N=No

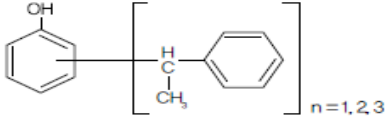
내분비계 장애를 유발하지 않는 대체재라 할지라도 수생독성을 유발
 현재 가장 많이 쓰는 계면활성제인 SLS의 경우 피부염을 유발
 지방산 에스테르를 이용한 대체 비이온 계면활성제 합성(MEE 등)

Nonylphenol 대체재: Styrenated phenol

- Nonylphenol의 특성은 유지하면서 유해성을 극복하기 위한
- 국내에서는 금호 화학에서 KUMANOX라는 제품을 생산

KUMANOX 3110

Formula



Chemical Name: Styrenated phenol
Molecular Weight: 220(average)
CAS NO.: 61788-44-1

Product Properties

| | |
|------------------|------------------------------|
| - Appearance | Slight yellow Viscous Liquid |
| - Color (G) | < 1.5 |
| - OH value | 230-260 |
| - Water cont, % | < 0.2% |
| - Viscosity(cps) | Max 300-600 at 25 ± 0.2°C |

Characteristics

- Good Color
- Low Viscosity, Non Volatile Contents.
- High OH Value
- Non-Toxic
- HI Performance: easy processing and application
- Excellent Adhesion
- Excellent Solubility for most solvents

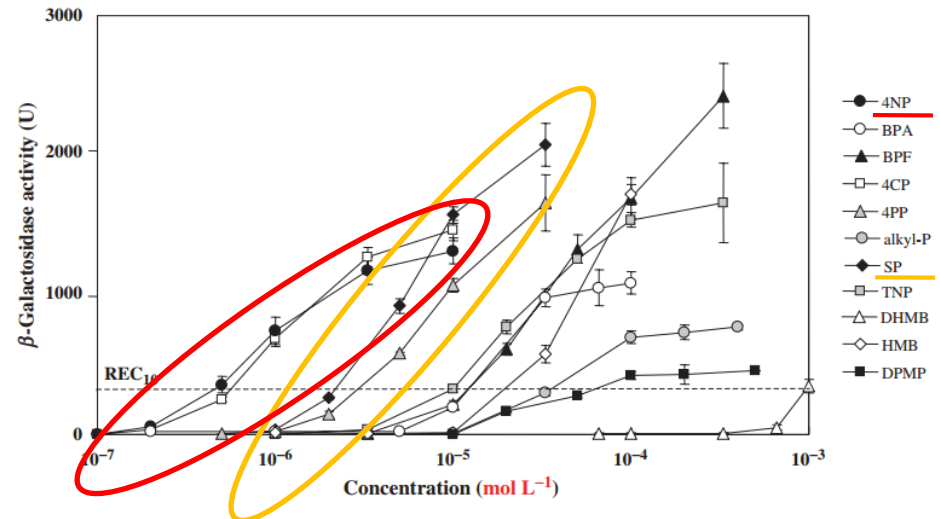


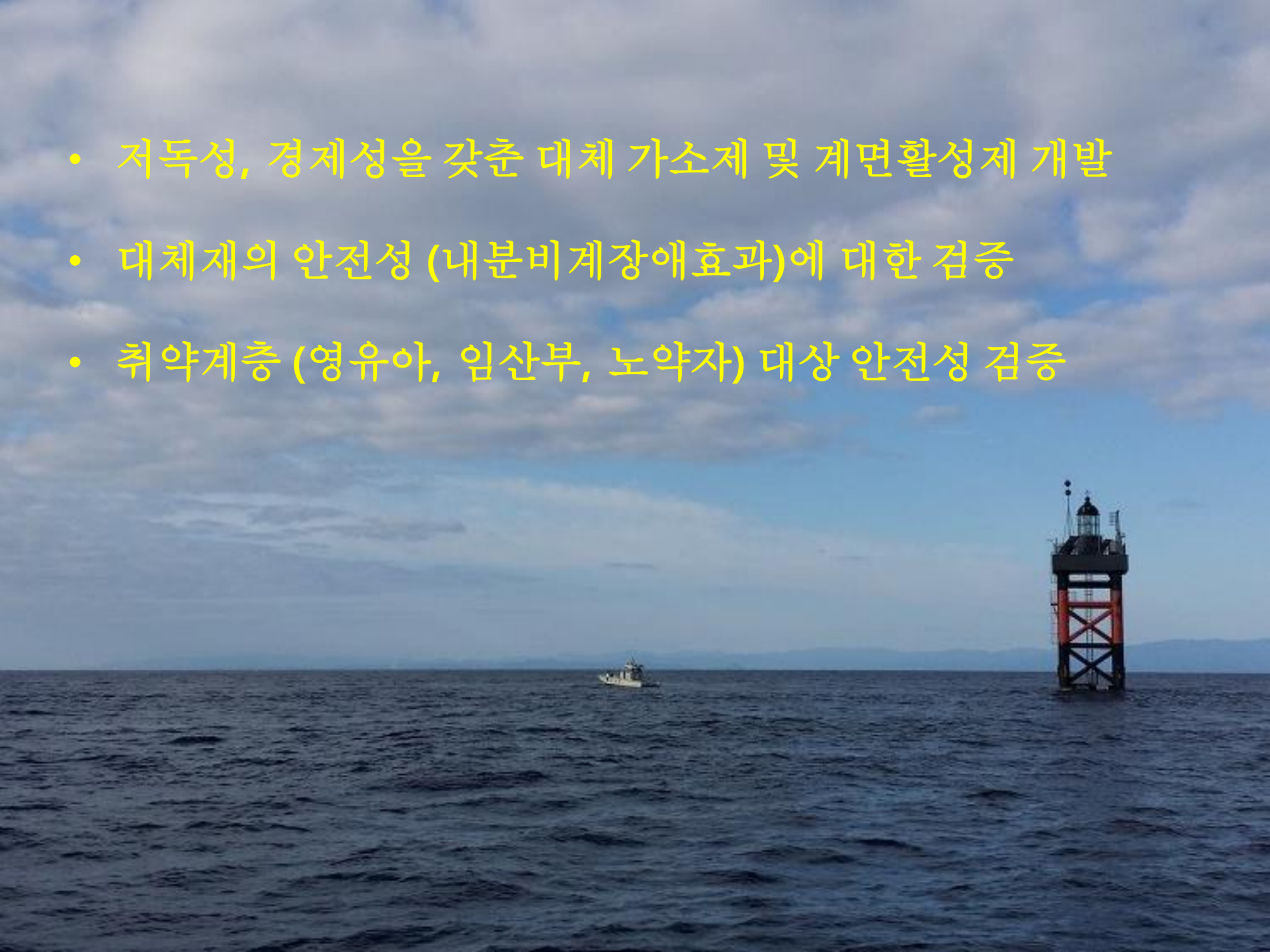
Figure 2. Dose response curves of estrogenic activity of nonylphenol (4NP), bisphenol A (BPA) bis (4-hydroxyphenyl) methane (BPF), 4-cyclohexylphenol (4CP), 4-phenylphenol (4PP), 4,4'-isopropylidenediphenol alkylphosphite (alkyl-p), styrenated phenol (mono 74%, SP), tris (nonylphenyl) phosphite (TNP), 2,2'-dihydroxy-4-methoxybenzophenone (DHMB), 2-hydroxy-4-methoxybenzophenone (HMB) and 2,4-Diphenyl-4-methyl-1-pentene (DPMP).

*2006 Food Additives & Contaminants ,Estrogenic activities of chemicals related to food contact plastics and rubbers tested by the yeast twohybrid assay , Yuko Ogawa , et al

Styrenated phenol (노랑) 역시 에스트로겐 활성을 나타냄

**Nonylphenol (빨강)보다는 높은 농도에서 에스트로겐 활성을 보이지
만 그 정도가 작지 않다.**

- 저독성, 경제성을 갖춘 대체 가스제 및 계면활성제 개발
- 대체재의 안전성 (내분비계장애효과)에 대한 검증
- 취약계층 (영유아, 임산부, 노약자) 대상 안전성 검증



2015 미래창조과학부 사회문제해결을 위한 시민연구사업

환경호르몬으로부터 국민의 건강을
보호하기 위한 기술개발 사업단
(2015. 6~ 2018. 4)



미래창조과학부



사업필요성 및 배경

환경호르몬 현황 / 문제점



요구기술 (RFP)

환경호르몬 (내분비계 장애물질, Endocrine Disruptor)

: 사람이나 동물의 내분비호르몬과 유사한 작용을 하는 외인성 화학물질로서 내분비계를 교란하여 인체건강에 해치는 물질

생식기능저하, 기형, 성조숙증, 암 유발 등 새로운 환경문제 대두

Endocrine Disruption

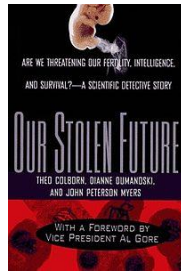


Prenatal Origins of Endocrine Disruption



소비, 생활양식의 변화로 내분비계 장애물질 노출기회 증가 영유아, 노약자, 임산부가 특히 취약

내분비계 장애물질 위해성 논란 관련정보 부재로 국민불안 가중



사회문제 해결 시민사업 필요성 대두

취약계층을 위한 저가보급형 환경호르몬 대체물질 개발 (노닐페놀, 프탈레이트, 비스페놀 A 대체제)

환경호르몬 다중 감지센서 개발

환경호르몬 안전성 평가기술 개발

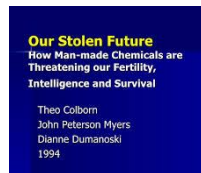
제조공정의 환경호르몬 인체노출 및 환경배출 저감공법 및 저감효과 평가모델 개발

환경호르몬 관리정책·법·제도개선 /대국민홍보체계 수립

- 비스페놀A 등 내분비계장애물질 '10년 국내 유통량은 '06년 대비 대폭 증가(21만톤, 55.9%),
- 국내 제조량은 18만톤 증가(24.9%)
- 내분비교란에 대한 충분한 연구 없이 대체물질 개발 및 사



New Review from TEDX: Common substitutes for bisphenol A (BPA) are hormonally active
 RSVP to hear Dr. Rochester discuss their results on Wednesday March 18, at 1 pm EDT



Our Stolen Future
 How Man-made Chemicals are Threatening our Fertility, Intelligence and Survival

Theo Colborn
 John Peterson Myers
 Dianne Dumanoski
 1994

사업목표

환경호르몬으로부터 국민의 건강을 보호하기 위한 기술개발

1년차
(2015)

원천개발: 환경호르몬대체물질 개발/공정도입

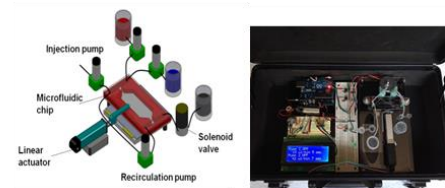
- 노닐페놀 대체물질 선별, 생산, 제조공정 확립
- 노닐페놀 대체물질 내분비교란 활성 평가
- 압타머 및 단백질 기반 환경호르몬 센서 개발
- 환경호르몬/대체물질에 관한 국내외 법제 및 정책조사



2년차
(2016)

확장개발: 확보된 제조공정을 통한 추가대체물질 시험 및 안전성평가

- 프탈레이트 대체물질 선별, 생산, 저감 제조공정 확립
- 프탈레이트 대체물질 내분비교란 활성 평가
- 환경호르몬 3종의 다중센서 기술 개발 / 자동화 분석장치 플랫폼 개발
- 환경호르몬 대체물질에 관한 국내외 법제 및 정책방향 설정



3년차
(2017)

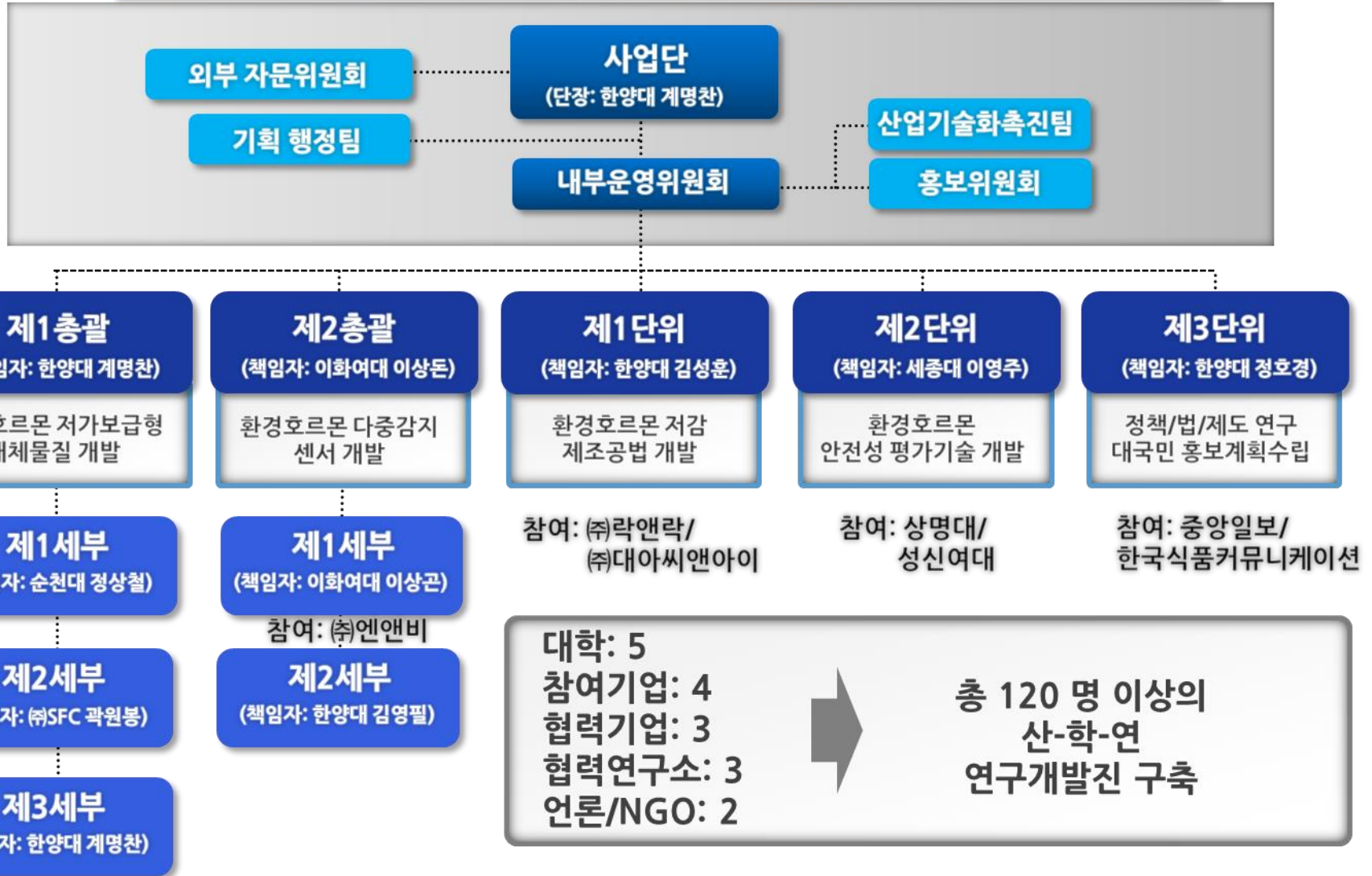
문제해결연구: 대체물질 및 시제품개발 및 안전성 평가

- 비스페놀 대체물질 선별, 생산, 저감 제조공정 확립
- 비스페놀 대체물질 내분비교란 활성 평가
- 자동화센서의 대체물질 개발 공정단계 적용
- 환경호르몬 관리 제도/입법안 제안 및 대국민 홍보



사업팀 구성

목표: 환경호르몬으로부터 국민의 건강을 보호하기 위한 기술개발



감사합니다.

