Table 4 Summary of the results of the newborn and young rat study of 2,4-di-*tert*-butylphenol

Newborn rat study				
Dose (mg/kg/day)	5	40	300	
Death	–	–	M: 2/12, F: 1/12	
Clinical signs	–	–	Decrease in locomotor activity bradypnea, hypothermia	
Body weight changes	–	–	9–25%↓	
Urinalysis	n.d.	n.d.	n.d.	
Hematological changes	–	–	–	
Blood biochemical changes	–	–	Various†	
Changes in relative organ weights	–	F: Liver 14%↑	Liver 39–51%↑, Kidney 37–41%↑ M: Spleen 24%↓	
Histopathological findings	–	F: Fatty degeneration in liver	Various changes in liver and kidney‡	
Developmental parameters	–	–	Slight delay in preputial separation	
Young rat study				
Dose (mg/kg/day)	5	20	75	300
Death	–	–	–	–
Clinical signs	–	–	–	–
Body weight changes	–	–	–	–
Urinalysis	–	–	–	UV↑ SG↓ OP↓
Hematological changes	–	–	–	Various§
Blood biochemical changes	–	–	F: Tcho↑ Pho↑	M: TB↑ F: Tcho↑ Pho↑
Changes in relative organ weights	–	–	F: Liver 13%↑	Liver 40–43%↑
Histopathological findings	n.d.	n.d.	–	Various changes in liver and kidney¶

Data on death are shown as no. of dead animals/no. of animals examined, according to sex. Statistically significant increases ($P < 0.05$) in body weights, urinalysis and blood biochemical parameters, and relative organ weights are shown as ↑, while decreases are shown as ↓. Changes observed only in males or females are shown as 'M' or 'F', respectively, while neither 'M' nor 'F' is mentioned in the case of changes noted in both sexes. †Increase in total bilirubin and decrease in the A/G ratio in both sexes, increase in γ-GTP in males, and increase in total protein and BUN in females were noted. ‡Various changes were observed as shown in Table 3. §Various hematological changes were noted such as decrease in hemoglobin and hematocrit and increase in segmented neutrophils in females and prolongation of PT and APTT in males. ¶Various changes were observed as shown in Table 5. OP: osmotic pressure; Pho: phospholipid; SG: specific gravity; TB: total bilirubin; Tcho: total cholesterol; UV: urine volume; –: no change; n.d.: not determined.

or critical histopathological damage (Koizumi *et al.* 2001). We here tried to apply this UETL approach to the present study. For 2TBP, clinical signs such as decrease in locomotor activity and ataxic gait were noted in most of the animals given 200 mg/kg (newborn rats) and 500 mg/kg (young rats) (Table 2). Furthermore, a 8–17% lowering of body weight was observed at 200 mg/kg in newborn rats, but not in the young rat study. Therefore, equivalent toxic effects to these observed at 500 mg/kg in young rats might be expected to appear at 100–150 mg/kg in newborn animals. The UETLs were concluded to be 100–150 and 500 mg/kg/day in newborn and young rats, respectively. In the case of DTBP, clear toxicity was observed at the top dose of 300 mg/kg in both newborn and young rat studies (Table 4), but the level of severity was very different, for example, deaths were only noted in the newborn cases. It was considered difficult to estimate the UETLs from the results of main studies only. However, the most critical endpoint for toxicity, mortality, was also noted at 100 mg/kg and more, and 500 mg/kg, in the dose-finding studies of newborn and young rats, respectively. Therefore, it would be possible to estimate the appropriate UETLs as the minimum lethal dose by taking the results of the dose-finding

studies into consideration. The UETLs were concluded to be 100 mg/kg/day for the newborn, and 500 mg/kg/day for young rats, at which one out of eight rats was found dead in both cases. These analyzes of UETLs, considering equivalence in toxic degree, showed 3.3–5.0 times higher susceptibility of newborn rats to 2TBP and DTBP than young rats, consistent with our analytical results for NOAELs.

Higher susceptibility of newborn rats was also demonstrated in our previous analyzes of five phenols (4-nitrophenol, 2,4-dinitrophenol, 3-aminophenol, 3-methylphenol and 2,4,6-trinitrophenol) (Koizumi *et al.* 2001, 2002, 2003; Takahashi *et al.* 2004), considered mainly due to their poor metabolic and excretory capacity (Horster 1977; Cresteil *et al.* 1986). It has actually been reported that UDP-glucuronyltransferase and sulfotransferase activities, when 4-nitrophenol is used as the substrate, are lower in microsomes prepared from livers of newborn rats, and that the elimination rate of 2,4-dinitrophenol from serum of newborn rabbits is markedly slower than in young adults (Gehring & Buerge 1969; Matsui & Watanabe 1982). Unfortunately, there is no information on the toxicity mechanism and toxicokinetics of both 2TBP

Table 5 Histopathological findings for the young rat study of 2,4-di-*tert*-butylphenol

Dose (mg/kg/day)	Grade	Scheduled-sacrifice group[†] 0	75	300	Recovery group 0	300
No. of animals examined (Male/Female)		6/6	6/6	6/6	6/6	6/6
Liver						
– Centrilobular hypertrophy of hepatocytes	+	0/0	0/0	4/4	0/0	0/0
Kidneys						
– Basophilic tubules	+	0/0	0/0	1/4	0/0	3/1
	++	0/0	0/0	4/0	0/0	2/0
	+++	0/0	0/0	1/1	0/0	1/0
– Granular casts	+	0/0	0/0	5/2	0/0	4/0
	++	0/0	0/0	1/1	0/0	0/0
– Proteinaceous casts	+	0/0	0/0	5/1	0/0	2/0
	++	0/0	0/0	1/0	0/0	0/0

†No histopathological examination was conducted for the 5 and 20 mg/kg scheduled-sacrifice groups. +, mild; ++, moderate; +++, marked.

and DTBP; however, the immature functions involved in the toxicokinetics in newborn rats would be implicated in the higher susceptibility, as in the case of five phenols previously analyzed. While there are very little data on toxicokinetics of environmental chemicals in the newborn, relatively plentiful information has been reported in humans for pharmaceuticals which are clinically applied during the early postnatal period. Recently, Ginsberg *et al.* (2002) conducted comparative analysis of pharmacokinetic parameters for 45 drugs in both children and adults, and showed half-lives in children aged two months or under to generally be two-fold longer than in adults.

As for the susceptibility of the newborn to toxicity of chemicals, although it is generally important to take the sensitivity of target organs and tissues themselves (toxicodynamics) into consideration besides toxicokinetics, there are insufficient data on differences between newborn and young/adult animals. For appearance of toxicity, which is the outcome of toxicokinetics and toxicodynamics, some comparative studies have relied on LD_{50} values (Goldenthal 1971; Sheehan & Gaylor 1990). However, it is not considered that information on acute toxicity at lethal dosage is appropriate when considering the susceptibility of newborn in risk assessment, because dose–response curves could differ, as mentioned above. With prolonged, subtoxic doses, which are basis for TDI or ADI, our series of comparative studies constitute the first systematic assessment, providing an important base for development of new methods of risk assessment of susceptibility of the newborn.

In conclusion, clinical signs and effects on the liver were observed for 2TBP, and hepatic and renal toxicity for DTBP. Although there were no clear differences in toxicity profiles between the newborn and young rats for both chemicals, the toxicity levels differed markedly. The susceptibility of the newborn to these chemicals appears to be 4–5 times higher than that of young animals.

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ORIGINAL ARTICLE

Comparative susceptibility of newborn and young rats to six industrial chemicals

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ABSTRACT   To elucidate the comparative susceptibility of newborn rats to chemicals, newborn and young animals were administered six industrial chemicals by gavage from postnatal days (PND) 4 to 21, and for 28 days starting at 5–6 weeks of age respectively, under the same experimental conditions as far as possible. As two new toxicity endpoints specific to this comparative analysis, presumed no-observed-adverse-effect-levels (pNOAELs) were estimated based on results of both main and dose-finding studies, and presumed unequivocally toxic levels (pUETLs) were also decided. pNOAELs for newborn and young rats were 40 and 200 for 2-chlorophenol, 100 and 100 for 4-chlorophenol, 30 and 100 for p-(α,α-dimethylbenzyl) phenol, 100 and 40 for (hydroxyphenyl)methyl phenol, 60 and 12 for trityl chloride, and 100 and 300 mg/kg/day for 1,3,5-trihydroxybenzene, respectively. To determine pUETLs, dose ranges were adopted in several cases because of the limited results of experimental doses. Values for newborn and young rats were thus estimated as 200–250 and 1000 for 2-chlorophenol, 300 and 500 for 4-chlorophenol, 300 and 700–800 for p-(α,α-dimethylbenzyl) phenol, 140–160 and 1000 for (hydroxyphenyl)methyl phenol, 400–500 and 300 for trityl chloride, and 500 and 1000 mg/kg/day for 1,3,5-trihydroxybenzene, respectively. In most cases, newborn rats were 2–5 times more susceptible than young rats in terms of both the pNOAEL and the pUETL. An exception was that young rats were clearly more susceptible than their newborn counterparts for trityl chloride.

Key Words: industrial chemicals, newborn rats, susceptibility

INTRODUCTION

In risk assessment of chemicals, the no-observed-adverse-effect-level (NOAEL) determined with repeated dose toxicity studies is generally divided by uncertainty factors (UFs) to obtain the tolerable daily intake (TDI) (Hasegawa *et al.* 2004). UFs include inter- and intraspecies differences, lack of data quality and the nature of observed toxicity. As TDI is an allowable lifetime exposure level for a chemical, at which no appreciable health risk would be expected over a lifetime, the NOAEL must be derived from lifetime exposure studies and appropriate reproductive/developmental studies, or their equivalents. Administration generally starts at the prepubertal stage (4–5 weeks old) or with young adults (10–12 weeks old) in rodent studies. Therefore, the suckling phase is the major remaining period where animals are not directly administered to chemicals. If susceptibility of infant animals to chemicals via direct

exposure was evidenced by appropriate comparative studies, the results would preferably be incorporated into the UF as one justification for lack of data quality.

In the latest decade, infant and child health has become a major focus (Landrigan *et al.* 2004), especially since endocrine disrupters became a contentious issue around the world (IPCS 2002). Since there are distinct differences in characteristics from the adult case (Dourson *et al.* 2002), particular attention must be paid to infant and child health. The Japanese government has therefore incorporated the newborn rat study (newborn study) into Existing Chemical Safety Programs as an especial project to comparatively determine susceptibility to 18 industrial chemicals. As the core of this program is to conduct 28-day repeated dose toxicity studies using young rats (young study) with untested chemicals from the existing list, chemicals for newborn studies were selected among the chemicals scheduled for young studies in the same year for the best comparison of data. Furthermore, we have had to newly establish a newborn rat study protocol because of the lack of any standard testing guidelines. Major differences of newborn from young studies are a shorter administration period (18 days only for the suckling phase) and additional examination of early functional, external and sexual development (Koizumi *et al.* 2001). Studies were conducted from 1995 to 1998 and we have already reported the results of comparative analysis for eight chemicals, showing newborn rats to be generally 2–4 fold more susceptible than young rats in most cases on basis of NOAEL and the unequivocally toxic level (UETL), the latter being uniquely defined in this program as doses inducing clear clinical toxic signs, death or critical histopathological damage (Koizumi *et al.* 2001, 2002, 2003; Fukuda *et al.* 2004; Takahashi *et al.* 2004; Hirata-Koizumi *et al.* 2005).

The purpose of this study is to obtain additional information on susceptibility of newborn rats to other chemicals. Here we selected the following six industrial chemicals, mostly phenolic compounds: 2-chlorophenol, 4-chlorophenol, p-(α,α-dimethylbenzyl) phenol (hydroxyphenyl)methyl phenol, trityl chloride and 1,3,5-trihydroxybenzene, because of structural similarity to endocrine-disrupting phenols, bisphenol A (Takahashi & Oishi 2001), and nonylphenol (Lee 1998). These chemicals have been used as an intermediate in dyes and an ingredient in pesticides (2-chlorophenol), an intermediate in dyes, bactericides and an ingredient in cosmetics (4-chlorophenol), an ingredient in surfactants, bactericides, an intermediate in pesticides and plasticizers (p-(α,α-dimethylbenzyl) phenol), an ingredient in resins ((hydroxyphenyl)methyl phenol), an intermediate in medicines (trityl chloride) and an ingredient in medicines, a stabilizer of synthetic rubbers and an adhesive of rubbers (1,3,5-trihydroxybenzene) (*Chemical Products' Handbook* 2004). Under the same experimental conditions as far as possible, we have examined the repeated dose toxicity of these chemicals in newborn and young rats and compared susceptibility for each. Previously we had applied NOAEL and UETL as estimated doses

or ranges of doses for comparison of chemical susceptibility, but we have decided to employ the new terminology of presumed NOAEL (pNOAEL) and presumed UETL (pUETL) in their place. As a result, in most cases newborn rats were more susceptible to these industrial chemicals than young rats in terms of both pNOAEL and pUETL.

MATERIALS

2-Chlorophenol (CAS no. 95-57-8, Lot no. OJL-15, purity: 99.49%) was obtained from Inui Corporation and prepared in olive oil; 4-chlorophenol (CAS no. 106-48-9, Lot no. PJF-3, purity: 99.29%) from Inui Corporation and in corn oil; p-(α,α-dimethyl-benzyl) phenol (CAS no. 599-64-4, Lot no. 101002, purity: 99.88%) from Sun TechnoChemical Inc. in olive oil; (hydroxyphe-nyl)methyl phenol (CAS no. 1333-16-0, Lot no. S980013, purity: 99.0% [2,2' isomer 14–18%, 2,4' isomer 44–48%, 4,4' isomer 26–32%]) from Mitsui Chemicals, Inc. in 0.5% CMC-Na solution containing 0.1% Tween 80; trityl chloride (CAS no. 76-83-5, Lot no. 1038, purity: 99.5%) from Kurogane Kasei Co. Ltd. in olive oil; and 1,3,5-trihydroxybenzene (CAS no. 108-73-6, Lot no. OS-12074, purity: 99.9%) from Ishihara Sangyou Co., Ltd. in olive oil. Test solutions were prepared at least once a week and were kept cool and in the dark until dosing. The stability was confirmed to be at least seven days under these conditions. All other reagents used in this study were specific purity grade.

METHODS

All animal studies were performed in five testing laboratories contracted to the Japanese Government, after we approved the test protocol.

Animals

Sprague-Dawley SPF rats [Crj:CD(SD)IGS] were purchased from Charles River Japan Inc. (Kanagawa, Japan) and maintained in an environmentally controlled room at 24 ± 2°C with a relative humidity of 55 ± 15%, a ventilation rate of more than 10 times per hour, and a 12:12 h light/dark cycle. For the studies of newborns, 20 pregnant rats (shipped in at gestation day 14) were allowed to deliver spontaneously. All newborns were separated from dams on postnatal day (PND) 3 and groups of 12 males and 12 females were selected and assigned to each of the four dose groups, including the controls. Twelve foster mothers were selected based on health and nursing conditions, and suckled the four males and four females assigned to each group up to weaning on PND 21 (termination of dosing and autopsy for half of the animals). After weaning, the rest of the animals for the recovery-maintenance group (see Study Design) were individually maintained for nine weeks. In the studies of young, four-week-old male and female rats were obtained and used at ages of 5–6 weeks after acclimation. All animals were allowed free access to a basal diet and water.

Study design (time schedule as described previously [Koizumi *et al.* 2001])

1. 18-day repeated dose study in newborn rats (newborn study)

In a dose-finding study, chemicals were administered by gastric intubation to newborn male and female rats on PNDs 4–21. Animals were examined for general behavior and body weights during the dosing period, and sacrificed at PND 22 for assessment of hematology, blood biochemistry, macroscopic findings and organ weights.

In the main study, newborn rats (12/sex/dose) were administered chemicals by gastric intubation on PNDs 4–21, the dosage being set on the basis of results of the dose-finding study. On PND 22, half of the animals were sacrificed and the rest were maintained for nine weeks without chemical treatment, and then sacrificed at 12 weeks of age (the recovery-maintenance group). During the study, general behavior and body weight were examined at least once a day and each week, respectively. In addition, developmental parameters were assessed, such as surface righting and visual placing reflex for reflex ontogeny, fur appearance, incisor eruption and eye opening for external development, and preputial separation, vaginal opening and estrous cycle for sexual development. Urinalysis (color, pH, occult blood, protein, glucose, ketone bodies, bilirubin, urobilinogen, sediment, volume of the urine and osmotic pressure) was conducted in the late recovery-maintenance period.

At weaning age PND 22 after the last treatment, blood was collected under anesthesia from the abdomen of all animals in the scheduled-sacrifice group. In the recovery-maintenance group, this was conducted at 85 days of age after overnight starvation. Blood was examined for hematological parameters such as the red blood cell count, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, white blood cell count, platelet count, reticulocyte count and differential leukocyte count, and for biochemistry (total protein, albumin, albumin/globulin ratio, glucose, total cholesterol, triglycerides, phospholipid, total bilirubin, urea nitrogen (BUN), creatinine, aspartate aminotransferase, alanine aminotransferase (ALT), alkaline phosphatase, γ-glutamyl transpeptidase (γ-GTP), calcium, inorganic phosphorus, sodium, potassium and chlorine). Prothrombin time and activated thromboplastin time were examined only in the recovery-maintenance group. The brain, pituitary gland, thymus, thyroids, heart, lungs, liver, spleen, kidneys, adrenals, testes, epididymides, ovaries and uterus were weighed, and these, with other macroscopically abnormal organs, were fixed in 10% buffered formalin-phosphate (following Bouin's fixation for testes and epididymides). Paraffin sections were routinely prepared and stained with hematoxylin-eosin for microscopic examination. All studies were conducted in compliance with the Good Laboratory Practice Act of the Japanese Government.

2. 28-day repeated dose study in young rats (young study)

In a dose-finding study, chemicals were administered by gastric intubation to five-week-old male and female rats for 14 days. The general behavior, body weight and food consumption were examined, and the animals were sacrificed the day after the last treatment for assessment of hematology, blood biochemistry, macroscopic findings and organ weights.

In the main study, 5–6 week old male and female rats were given chemicals by gastric intubation daily for 28 days and sacrificed after overnight starvation following the last treatment (scheduled-sacrifice group). Recovery groups were maintained for two weeks without chemical treatment and sacrificed at 11 or 12 weeks of age. Rats were examined for general behavior, body weight, food consumption, urinalysis, hematology and blood biochemistry, necropsy findings, organ weights and histopathological findings in compliance with the Test Guideline in the Japanese Chemical Control Act (Official Name: Law Concerning the Examination and Regulation of Manufacture, etc. of Chemical Substances) under Good Laboratory Practice conditions.

Statistical analysis

Quantitative data were analyzed by Bartlett's test (Bartlett 1937) for homogeneity of distribution. When homogeneity was recog-

nized, Dunnett's test (Dunnett 1964) was conducted for comparison between control and individual treatment groups. If not homogenous, the data were analyzed using Steel's multiple comparison test (Steel 1959) or the mean rank test of the Dunnett type (Hollander & Wolfe 1973). For qualitative data such as histopathological findings, the Mann–Whitney's *U*-test (Mann & Whitney 1947) or the Fisher's exact test (Fisher 1973) were performed.

Adoption of pNOAEL and pUETL

NOAEL is a measure used in toxicity studies for the greatest dose at which no adverse effects are observed. No toxicologically meaningful changes are excluded for any grounds, including increase of relative organ weights without any other related changes. As the present purpose was to elucidate susceptibility of newborn rats to chemicals as compared with young rats as accurately as possible, simple application of NOAELs obtained from newborn and young main studies was considered not to be necessarily appropriate even though the dose setting is pertinent. Therefore, we newly defined a pNOAEL as the most likely estimated no-adverse-effect-dose on the basis of data from both main and dose-finding studies. As urinalysis and histopathological examination were not conducted in both dose-finding studies, and the administration period in young dose-finding study was half of the main study, we carefully weighed how the results from the dose-finding study should be taken into account, especially concerning the type of toxicity. In order to consider equivalently toxic intensity doses for newborn and young rats, we also newly defined a pUETL, although this is not without problems given the limited dose points. Therefore, in the most cases, the appropriate pUETL for either newborn or young rats was chosen first, thereafter the matching pUETL or the range of pUETL was speculated to assess equivalent toxicity, considering the entire body of data.

RESULTS

2-Chlorophenol (Table 1)

The newborn investigation was conducted at doses of 0, 20, 100, and 500 mg/kg for the dose-finding and 0, 8, 50, and 300 mg/kg for the main study. The young investigation was conducted at doses of 0, 100, 200, and 500 mg/kg for the dose-finding and 0, 8, 40, 200, and 1000 mg/kg for the main study.

Major toxic effects on the central nervous system (CNS) were found in both sexes of newborn and young rats. In the newborn study, tremors appeared within five minutes and disappeared within four hours in most animals at 300 mg/kg. Hypoactivity and an abnormal gait were also observed in a few cases. The histopathological examination showed slight to moderate basophilic renal tubules in more than half the animals of both sexes, without relative kidney weight changes (increase by 8% for males, 4% for females). In addition to these effects, the body weights of both sexes at this dose were transiently decreased. At 50 mg/kg, only one female showed tremors once from 15 to 30 minutes on day nine after the dosing start. There were no chemical-related changes in developmental parameters. In the young study, most animals of both sexes sporadically showed various effects on the CNS such as tremors, hypoactivity, and an abnormal gait within three hours after dosing at 1000 mg/kg. Most animals also exhibited slight centrilobular hypertrophy of hepatocytes, suggesting a compensatory response to a requirement for hepatic metabolism. In the dose-finding study, no toxic signs were observed, but the information was limited because of the small number of animals, the short administration period, and the lack of histopathological examination. There were no chemical-related abnormalities at 200 mg/kg in the main study.

Although the NOAEL was 8 mg/kg/day for newborn rats based on the main study results, this value was concluded to be too low

Table 1 Toxicity findings for 2-chlorophenol in the newborn and young rat main studies

	Newborn study (mg/kg)					Young study (mg/kg)			
	0	20†	50	100†	300	0	200	500†	1000
Male									
General behavior									
Tremors	0/12	0/4	0/12	0/4	11/12	0/12	0/12	0/3	4/12
Hypoactivity	0/12	0/4	0/12	0/4	2/12	0/12	0/12	0/3	8/12
Abnormal gait	0/12	0/4	0/12	0/4	1/12	0/12	0/12	0/3	4/12
Histopathology									
Renal tubules, basophilic	0/6	no data	0/6	no data	4/6	0/6	0/6	no data	0/6
Centrilobular hypertrophy	0/6	no data	0/6	no data	0/6	0/6	0/6	no data	6/6
Female									
General behavior									
Tremors	0/12	0/4	1/12	0/4	12/12	0/12	0/12	0/3	5/12
Hypoactivity	0/12	0/4	0/12	0/4	3/12	0/12	0/12	0/3	5/12
Abnormal gait	0/12	0/4	0/12	0/4	1/12	0/12	0/12	0/3	7/12
Histopathology									
Renal tubules, basophilic	0/6	no data	0/6	no data	5/6	0/6	0/6	no data	0/6
Centrilobular hypertrophy	0/6	no data	0/6	no data	0/6	0/6	0/6	no data	5/6

Only data for items showing change are included in this table. Data are numbers of animals with the change of the total examined. †indicates dose and data from the dose-finding study. All newborn animals died by the 9th dosing day at 500 mg/kg in the dose-finding study. Body weights of both sexes were only transiently, but not finally reduced, at 300 mg/kg in the newborn main study. Clinical signs in newborn rats were not observed at doses of 20 and 100 mg/kg in the dose-finding study.

because of the absence of clinical signs at 20 and 100 mg/kg in the dose-finding study, and only one female showed tremors once at 50 mg/kg in the main study. The pNOAEL for newborn rats was therefore estimated to be 40 mg/kg/day, a little below the 50 mg/kg. For young rats, the pNOAEL can be considered to be 200 mg/kg/day because of the limited information at 500 mg/kg in the dose-finding study. The toxicity at 300 mg/kg for newborn rats seemed to be slightly higher than that at 1000 mg/kg for young rats, because of the transient depression of body weight found limited to the former cases, although the toxicity profile regarding the CNS was very similar in newborn and young rats. The dose for newborn rats showing the same toxic intensity, as that for young rats at 1000 mg/kg, is considered to be slightly lower than 300 mg/kg, at 200–250 mg/kg/day. Therefore, pUETLs of 200–250 and 1000 mg/kg/day may be considered equivalent doses for newborn and young rats, respectively.

4-Chlorophenol (Table 2)

The newborn investigation was conducted at doses of 0, 20, 100, and 500 mg/kg for the dose-finding and 0, 12, 60, and 300 mg/kg for the main study. With young rats doses of 0, 20, 100, and 500 mg/kg were applied in both dose-finding and main studies.

Toxic effects on the CNS were observed in both sexes of newborn and young rats. Most newborn rats at 500 mg/kg in the dose-finding study showed tremors, hypoactivity, bradypnea and hypothermia, and died. All newborn rats at 300 mg/kg exhibited tremors, mostly within 15 minutes to one hour, but these completely disappeared within four hours after dosing. There were no abnormalities at 100 mg/kg in the dose-finding, and 60 and 12 mg/kg in the main study. No developmental abnormalities were observed at any dose in the newborn dose-finding and main studies. In the young study, tremors, tachypnea and salivation were observed from five to 30 minutes after dosing in most animals in both sexes at 500 mg/kg. There were no other dose-dependent changes at any dose.

The pNOAEL for newborn rats is considered to be 100 mg/kg/day, because CNS toxicity was not observed at 100 mg/kg in the dose-finding study. The pNOAEL for young rats must be set at 100 mg/kg/day, because there were no doses set between 100 and 500 mg/kg. Although the toxicity profile regarding the CNS differed to some extent between newborn rats at 300 mg/kg and young rats at 500 mg/kg with respect to symptom appearance and duration, the same level can be concluded, considering the specific characteristics of the newborn body. Thereby, pUETLs of 300 and 500 mg/kg/day were estimated as appropriate for newborn and young rats, respectively.

p-(α,α-Dimethylbenzyl) phenol (Table 3)

The newborn investigation was conducted at doses of 0, 30, 100, and 300 mg/kg for both dose-finding and main studies. The young investigation was conducted at doses of 0, 250, 500, and 1000 mg/kg for dose-finding and 0, 100, 300, and 1000 mg/kg for the main study.

No newborn animals died although the body weights of both sexes were transiently lowered at 300 mg/kg (8% maximum decrease). General behavior, functional parameters and urinalysis, hematology and biochemistry data were all within normal ranges except for high urinary volume in males and high BUN in females at 300 mg/kg. The relative kidney weights were increased more than double at 300 mg/kg in both sexes, and dilation of tubules and papillary ducts was observed at relatively high grades in kidneys of both sexes, with no complete recoveries even after a nine-week recovery-maintenance period. Such histopathological change in kidneys was also slightly observed at 100 mg/kg in both sexes. In addition, there were effects on the endocrine systems, despite no effects on sexual differentiation. Absolute testicular weights were reduced by 16% at 300 mg/kg and ovary weights by 26% at 100

Table 2 Toxicity findings for 4-chlorophenol in the newborn and young rat main studies

	Newborn study (mg/kg)				Young study (mg/kg)		
	0	60	100†	300	0	100	500
Male							
General behavior							
Tremors	0/12	0/12	0/4	12/12	0/12	0/6	12/12
Tachypnea	0/12	0/12	0/4	0/12	0/12	0/6	11/12
Salivation	0/12	0/12	0/4	0/12	0/12	0/6	9/12
Histopathology							
Kidney	0/6	0/6	no data	0/6	0/6	0/6	0/6
Liver	0/6	0/6	no data	0/6	0/6	0/6	0/6
Female							
General behavior							
Tremors	0/12	0/12	0/4	12/12	0/12	0/6	11/12
Tachypnea	0/12	0/12	0/4	0/12	0/12	0/6	9/12
Salivation	0/12	0/12	0/4	0/12	0/12	0/6	8/12
Histopathology							
Kidney	0/6	0/6	no data	0/6	0/6	0/6	0/6
Liver	0/6	0/6	no data	0/6	0/6	0/6	0/6

Data are numbers of animals with the change of the total examined. All newborn males and 3/4 females died at 500 mg/kg in the dose-finding study. †indicates dose and data from the dose-finding study.

Table 3 Major toxicity findings for p-(α,α-dimethylbenzyl) phenol in the newborn and young rat main studies

	Newborn study (mg/kg)				Young study (mg/kg)			
	0	30	100	300	0	100	300	1000
Male								
Dead or moribund	0/12	0/12	0/12	0/12	0/14	0/7	0/7	3/14
ALT, γ-GTP	/	–	–	–	/	–	–	↑
BUN, Creatinine	/	–	–	–	/	–	–	↑
Relative liver weight	/	–	–	–	/	–	↑	↑
Relative kidney weight	/	–	–	↑	/	–	–	↑
Stomach, hyperplasia	0/6	0/6	0/6	0/6	0/7	0/7	0/7	1/6
Liver, proliferation bile ducts	0/6	0/6	0/6	0/6	0/7	0/7	0/7	6/6
Kidney, regeneration	0/6	0/6	0/6	0/6	3/7	3/7	5/7	6/6
Kidney, dilatation	0/6	0/6	1/6	6/6	0/7	0/7	0/7	6/6
Female								
Dead or moribund	0/12	0/12	0/12	0/12	0/14	0/7	0/7	1/14
ALT, γ-GTP	/	–	–	–	/	–	–	↑
BUN, Creatinine	/	–	–	↑,–	/	–	–	–
Relative liver weight	/	–	–	–	/	–	–	↑
Relative kidney weight	/	–	–	↑	/	–	–	↑
Stomach, hyperplasia	0/6	0/6	0/6	0/6	0/7	0/7	0/7	3/7
Liver, proliferation bile ducts	0/6	0/6	0/6	0/6	0/7	0/7	0/7	7/7
Kidney, regeneration	0/6	0/6	0/6	0/6	0/7	1/7	0/7	7/7
Kidney, dilatation	0/6	0/6	2/6	6/6	0/7	0/7	0/7	4/7

Only critical data are shown in this table. Data are numbers of animals with the change of the number examined. Slashes and bars mean no statistical significance as compared to controls. ↑ indicates significant increase at $P < 0.05$. Relative kidney weights were increased 2.5- and 2.1-fold for males and females at 300 mg/kg in the newborn study. For the young study, 14 males and 14 females (half for examination of recovery) were assigned to each group but 6 males and 7 females at 1000 mg/kg were re-assigned for 28-day examination because of deaths.

and 300 mg/kg. The absolute ovary weights were still lowered by 32% at 300 mg/kg after the recovery-maintenance period. Increased numbers of atretic follicles were found in ovaries of half of the females at 300 mg/kg at the end of the dosing period, and most females continued to show various changes such as decreased numbers of corpa luteua in the ovaries and hypertrophy of endometrial epithelium in the uteri, after the recovery-maintenance period.

In the young study, two males and one female died, and one male was killed in a moribund condition at 1000 mg/kg. The final body weights were reduced by 18%, limited to males. On urinalysis, both sexes showed irregularly sized particles of a black substance, accompanied by 2–4 fold elevation of urine volume. Clear changes of several biochemical parameters such as ALT, γ-GTP, BUN, and creatinine, increases of relative liver and kidney weights, and histopathological changes in the forestomach (squamous hyperplasia), liver (bile duct proliferation), and kidney (regeneration of tubular epithelium and dilatation of tubules) were also observed at 1000 mg/kg. A dose of 300 mg/kg was considered to cause slight toxicity, because the abnormal urinary contents described above were found in half of both sexes and a slightly elevated incidence of mild regeneration of the tubular epithelium was noted in male kidneys. After the two-week recovery period, the pathological changes in male kidneys at 1000 mg/kg continued to be evident. There were no signs of toxicity at 250 and 500 mg/kg in the dose-finding study although the administration period was only half and urinalysis and histopathological examinations were not performed.

The pNOAEL of 30 mg/kg/day for newborn rats is clear and one of 100 mg/kg/day for young rats is reasonable because of slight toxicity at 300 mg/kg in the main study and limited information at 250 mg/kg in the dose-finding study. Toxicity for newborn rats was evident at 300 mg/kg as all animals of both sexes showed histopathological changes in kidneys, with increased relative weights. However, the degree of toxicity for young rats at 1000 mg/kg was obviously much stronger than that of newborn rats at 300 mg/kg, which appeared to be equivalent to doses of 700–800 mg/kg in young rats. Therefore, pUETLs of 300 and 700–800 mg/kg/day may be appropriate for newborn and young rats, respectively. It should be specially noted that this chemical may have endocrine disrupting properties, especially against females, when given only during the suckling phase.

(Hydroxyphenyl)methyl phenol (Table 4)
The newborn investigation was conducted at doses of 0, 20, 60, and 200 mg/kg for dose-finding and 0, 16, 40, and 100 mg/kg for the main study. The young study was conducted at doses of 0, 100, 500, and 1000 mg/kg for dose-finding and 0, 8, 40, 200, and 1000 mg/kg for the main study.

Common changes were limited to depression of body weight and death at high doses in newborn and young rats. The highest dose of 100 mg/kg in the newborn main study did not cause any changes, but half the animals at 200 mg/kg in the newborn dose-finding study died, without accompanying liver weight changes in surviving

Table 4 Major toxicity findings for (hydroxyphenyl)methyl phenol in the newborn and young rat main studies

	Newborn study (mg/kg)			Young study (mg/kg)			
	0	100	200†	0	40	200	1000
Male							
Dead or moribund	0/12	0/12	3/6	0/12	0/12	0/12	0/12
Final body weight	/	–	↓	/	–	–	↓
Total cholesterol	/	–	↑	/	–	–	↓
Relative liver weight	/	–	–	/	–	–	↑
Stomach, hyperplasia	0/6	0/6	no data	0/6	0/6	0/6	6/6
Liver, centrilobular hypertrophy	0/6	0/6	no data	0/6	0/6	2/6	4/6
Female							
Dead or moribund	0/12	0/12	3/6	0/12	0/12	0/12	1/12
Final body weight	/	–	(↓)	/	–	–	(↓)
Total cholesterol	/	–	–	/	↓	↓	↓
Relative liver weight	/	–	–	/	–	↑	↑
Stomach, hyperplasia	0/6	0/6	no data	0/6	0/6	0/6	6/6
Liver, centrilobular hypertrophy	0/6	0/6	no data	0/6	0/6	0/6	4/6

Only critical data are shown in this table. † indicates a dose from the dose-finding study. Numbers are for animals with the feature in the total examined. Slashes and bars mean no statistical significance as compared with controls. ↑ indicates significant increase $P < 0.05$. ↓ indicates significant decrease at $P < 0.05$. () indicates that statistical significance was not obtained. Final body weights of surviving newborn males at 200 mg/kg in the dose-finding study were reduced by 30% (14% for females, not significant), respectively. Final body weights of young male rats at 1000 mg/kg in the main study were decreased by 11.8% (5.7% for females, not significant). Increase of relative liver weights was 13% in females at 200 mg/kg, and 16 and 27% in males and females at 1000 mg/kg in the young main study.

animals. There were no chemical-related changes with other examinations, including developmental parameters. In the young study, one female became moribund and the final body weights of males were decreased at 1000 mg/kg. All animals of both sexes at this dose showed squamous hyperplasia of the forestomach or limiting ridge with ulceration, and two-thirds of the animals featured centrilobular hypertrophy of hepatocytes with decrease of total cholesterol (29–51% drop) and increase of relative liver weight. At 200 mg/kg, low incidences of centrilobular hypertrophy in the livers of males and slight increase of liver weights in females with low total cholesterol (45% drop) were found. No toxicity was apparent at 40 mg/kg in the main study. No toxicity was also found at 100 mg/kg in the dose-finding study, but a histopathological examination was not conducted. There were no abnormalities on hematological examination and urinalysis at any dose.

The pNOAEL is considered to be 100 mg/kg/day for newborn rats and 40 mg/kg/day may be appropriate for young rats because of the limited information at 100 mg/kg in the dose-finding study. Although toxicity at 1000 mg/kg for young rats was evident, the dose inducing the same effects in newborn rats was clearly less than 200 mg/kg, because half of the animals died at this dose. We speculate that the dose range for one death in 12 newborn rats would be within 140–160 mg/kg. It is clear that the dose–response curve is much steeper for newborn than young rats. Based on our consideration, pUETLs of 140–160 and 1000 mg/kg/day may be equivalent for newborn and young rats, respectively.

Trityl chloride (Table 5)

The newborn investigation was conducted at doses of 0, 20, 60, 200, and 600 mg/kg for dose-finding and 0, 12, 60, and 300 mg/kg for the main study. The young investigation was conducted at doses

of 0, 30, 100, 300, and 1000 mg/kg for dose-finding and 0, 12, 60, and 300 mg/kg for the main study.

Common effects were observed in livers of newborn and young rats. In the newborn study, increase of relative liver weights were shown at 60 mg/kg and more in both sexes and centrilobular hypertrophy of hepatocytes was noted in 300 mg/kg females. In the dose-finding newborn study, one female died and increase of relative liver weights of both sexes at 600 mg/kg was more evident with low body weights (11.3% drop for males, 13.8% for females). There were no chemical-related changes with other examinations, including developmental parameters. In the young study, both sexes at 60 mg/kg showed a high incidence of centrilobular hypertrophy of hypetocytes with limited increases of relative liver weights (10–14%). At 300 mg/kg, soft feces and mucosal thickening of cecum in most animals were observed in addition to more extensive hepatic changes. Although relative kidney weights were increased at 300 mg/kg in males and 60 and 300 mg/kg in females, there were no renal histopathological findings. Hematological and blood chemical examinations revealed several slight to moderate changes (56% as the maximum) in fibrinogen, ALT, total cholesterol and glucose, as well as prolongation of prothrombin and activated thromboplastin times, at 300 mg/kg.

pNOAELs of 60 and 12 mg/kg/day for newborn and young rats appear appropriate because of the lack of information at higher doses in the dose-finding study, which showed no toxicity but without histopathological examination. The dose of 300 mg/kg in the young main study was a clear toxic level, but intensity was much stronger than that at 300 mg/kg in the newborn main study, while less that at 600 mg/kg in the dose-finding study. Based on these data, the toxicity with 300 mg/kg for young rats is considered to be within the range with 400–500 mg/kg for newborn rats.

Table 5 Major toxicity findings for trityl chloride in the newborn and young rat main studies

	Newborn study (mg/kg)				Young study (mg/kg)			
	0	60	300	600†	0	12	60	300
Male								
Death	0/12	0/12	0/12	0/6	0/12	0/6	0/12	0/12
Final body weight	/	–	–	↓	/	–	–	↓
ALT, Total cholesterol	/	–	–	–	/	–	–	↑
Relative liver weight	/	↑	↑	↑	–	–	↑	↑
Relative kidney weight	/	–	–	–	–	–	–	↑
Cecum, thickening	0/6	0/6	0/6	no data	0/6	0/6	0/6	5/6
Liver, centrilobular hypertrophy	0/6	0/6	0/6	no data	0/6	0/6	3/6	6/6
Female								
Death	0/12	0/12	0/12	1/6	0/12	0/6	0/12	0/12
Final body weight	/	–	–	↓	/	–	–	–
ALT, Total cholesterol	/	–	–	–	/	–	–	-,↑
Relative liver weight	/	↑	↑	↑	–	–	↑	↑
Relative kidney weight	/	–	–	–	–	–	↑	↑
Cecum, thickening	0/6	0/6	0/6	no data	0/6	0/6	2/6	5/6
Liver, centrilobular hypertrophy	0/6	0/6	4/6	no data	0/6	0/6	5/6	6/6

Only critical data are shown in this table. †indicates a dose from the dose-finding study. Numbers are for animals with the feature in the total examined. Slashes and bars mean no statistical significance as compared to controls. ↑ indicates significant increase $P < 0.05$. ↓indicates significant decrease at $P < 0.05$. Relative liver weights were increased by 11% for males and 8% for females at 60 mg/kg, and 29% for both sexes at 300 mg/kg in the newborn main study and by 44% for males and 46% for females at 600 mg/kg in the newborn dose-finding study. Body weight depression in males (13%) and an increase of relative liver weights (32% for males, 40% for females) were observed at 300 mg/kg in the young main study.

Therefore, pUETLs of 400–500 and 300 mg/kg/day are proposed as appropriate for newborn and young rats, respectively.

1,3,5-Trihydroxybenzene (Table 6)
The newborn investigation was conducted at doses of 0, 100, 500, and 1000 mg/kg for dose-finding and at 0, 20, 100, and 500 mg/kg for the main study. The young investigation was conducted at doses of 0, 100, 250, 500, and 1000 mg/kg for dose-finding and at 0, 30, 100, 300, and 1000 mg/kg for the main study.

Common changes were observed in the thyroids and liver. The only toxic change in newborn main study was hypertrophy of thyroid follicular cells with increase in relative thyroid weights in both sexes at 500 mg/kg. Increased relative liver weights in females were not accompanied by any histopathological changes. Although decrease of adrenal weight and histopathological alterations such as vacuolization and pigmentation were noted at the end of the dosing and recovery-maintenance periods, these were always slight and not dose-dependent. There were no chemical-related changes with other examinations, including developmental parameters, in newborn rats. In the young study, similar effects on the thyroids and liver were found at 1000 mg/kg, but the incidence of thyroid histopathological changes was slightly less than in newborn animals at 500 mg/kg.

pNOAELs of 100 and 300 mg/kg/day for newborn and young rats can be considered appropriate because of the lack of data with dose settings between 100 to 500 mg/kg in the newborn, and no histopathological examination at 500 mg/kg in the young dose-finding study. The degree of toxicity at 1000 mg/kg for young rats was almost equal to that at 500 mg/kg for newborn rats. Therefore,

pUETLs of 500 and 1000 mg/kg/day are proposed as equivalents for newborn and young rats, respectively.

DISCUSSION

More than 100 000 industrial chemicals are now in use around the world and sufficient toxicity information is available for only a small proportion. The Japanese government started the Existing Chemical Safety Program to obtain minimal toxicity data sets from 28-day toxicity studies using young rats for high production volume chemicals lacking toxicity information. For the present six targeted chemicals, we found toxicity information for only two chemicals by literature search. Daniel *et al.* (1993) reported no toxic effects of 2-chlorophenol on oral administration to male and female Sprague Dawley rats at up to 257 mg/kg for 10 days or 150 mg/kg for 90 days. Our results were consistent with their data, as we found no toxicity at 500 mg/kg in young dose-finding study (14 days administration) and at 200 mg/kg in the young study (28 days), while further providing information on CNS effects at higher doses. As for (hydroxyphenyl)methyl phenol, consisting of bisphenol D, E, and F isomers, bisphenol F has been reported to have estrogenic potential evidenced by several *in vitro* and *in vivo* experiments (Hashimoto *et al.* 2001; Yamasaki *et al.* 2002; Stroheker *et al.* 2003). However, we could not establish any such activity in this study. Our results are reasonable because oral administration of bisphenol F increased relative uterus weights only at more than 100 mg/kg, but not 50 mg/kg given during PNDs 22–25 (Stroheker *et al.* 2003), while our highest dose of (hydroxyphenyl)methyl phenol was equivalent to 30 mg/kg of bisphenol F.

Table 6 Major toxicity findings for 1,3,5-trihydroxybenzene in the newborn and young rat main studies

	Newborn study (mg/kg)			Young study (mg/kg)		
	0	100	500	0	300	1000
Male						
Relative organ weight						
Liver	/	–	–	/	–	↑
Thyroids	/	–	↑	/	–	(↑)
Histopathology						
Liver	0/6	0/6	0/6	0/6	0/6	0/6
Thyroids, hypertrophy	0/6	0/6	4/6	0/6	0/6	2/6
Female						
Relative organ weight						
Liver	/	–	↑	/	–	↑
Thyroids	/	–	(↑)	/	–	(↑)
Histopathology						
Liver	0/6	0/6	0/6	0/6	0/6	0/6
Thyroids, hypertrophy	0/6	0/6	5/6	0/6	0/6	4/6

Only critical data are shown in this table. Slashes and bars mean no statistical significance as compared with controls. ↑ indicates significant increase $P < 0.05$ (except in parentheses where statistical significance was not attained). Numbers are for animals with the feature in the total examined. Increase of relative organ weights at 500 mg/kg in the newborn main study was observed for thyroids (39% for males, 24% for females) and liver (9% for females). Increase of relative organ weights at 1000 mg/kg in the young main study was observed for thyroids (14% for males, 19% for females) and liver (23% for males and 9% for females).

Table 7 Comparative susceptibility of newborn and young rats to the six chemicals

	Newborn study		Young study		pNOAEL	pUETL
	pNOAEL	pUETL	pNOAEL	pUETL	Young/Newborn	Young/Newborn
	mg/kg/day		mg/kg/day			
2-Chlorophenol	40	200–250	200	1000	5.0	4.0–5.0
4-Chlorophenol	100	300	100	500	1.0	1.7
p-(α,α-Dimethylbenzyl) phenol	30	300	100	700–800	3.3	2.3–2.7
(Hydroxyphenyl) methyl phenol	100	140–160	40	1000	0.4	6.3–7.1
Trityl chloride	60	400–500	12	300	0.2	0.6–0.8
1,3,5-Trihydroxybenzene	100	500	300	1000	3.0	2.0

Although there has been no reports for p-(α,α-dimethylbenzyl) phenol, it causes endocrine disruption and possible antiestrogenic activity, when administered to newborn female rats in this study. Therefore, further studies on this chemical should be conducted to elucidate the mechanisms, because the present investigation did not indicate any effects on sexual differentiation such as preputial separation, vaginal opening and the estrous cycle.

For our focus on the comparative sensitivity of newborn and young rats to chemicals, two toxicity endpoints, pNOAEL and pUETL, were newly defined as appropriate, considering the entire data sets from both main and dose-finding studies. We believe that this alternative assessment approach allowed us to make more realistic comparisons between newborn and young rats under the same experimental conditions as far as possible.

The ratios of pNOAELs for chemicals between newborn and young rats may provide an additional UF value in risk assessment according to susceptibility of newborn rats, because regulatory limit values for chemicals to protect public health of humans,

including infants, are derived from the division of NOAEL by UFs. The data in Table 7 indicate newborn rats to be 1–5 times more susceptible to four of the tested chemicals, 2- and 4-chlorophenols, p-(α,α-dimethylbenzyl) phenol and 1,3,5-trihydroxybenzene, than young rats in terms of the pNOAELs, similar to the results of previous analyzes of five phenolic chemicals, 4-nitro-, 2,4-dinitro-, 2,4,6-trinitro-, 3-methyl- and 3-amino-phenols (Koizumi et al. 2001, 2002, 2003; Takahashi et al. 2004). Immaturity in the detoxification potential of phase 1 and phase 2 enzymes in newborn animals may be the major cause of higher toxicity in newborn rats (Rich & Boobis 1997; Gow et al. 2001), because these chemical classes are probably direct toxicants. In the case of (hydroxyphenyl)methyl phenol, the pNOAEL (100 mg/kg/day) for newborn rats was 2.5 times higher than that (40 mg/kg/day) for young rats, but it can be speculated that values are in practice rather similar because the toxicity for young rats at the high dose, 200 mg/kg, was only slight (Table 4). As for trityl chloride, newborn rats were obviously less susceptible (0.2 for the pNOAEL ratio). Similar results were

also reported from our previous analysis for bromoalkanes (Hirata-Koizumi *et al.* 2005) and may be explained by mechanisms of action and metabolic characteristics of newborn rats. As this class of chemicals possibly requires metabolism to act as toxicants, the relatively mature metabolic enzyme status of young rats would be expected to provide toxic intermediates by metabolic activation to a greater extent than in newborn rats, as evidenced by data for previously reported chemicals (Onkenhout *et al.* 1986; Kennedy *et al.* 1993). Other compounds such as acetaminophen, bromobenzene, and carbon tetrachloride have also been shown to not produce liver injury in neonatal animals at doses that are hepatotoxic to adults (Gregus & Klaassen 1998).

The ratios of pUETLs, doses inducing the same degree of toxicity in newborn and young rats, were almost the same as for pNOAELs with the direct toxicants, as shown in Table 7. However, newborn rats were considerably more susceptible to (hydroxyphenyl)methyl phenol when considering the pUETL, due to the much steeper dose–response curve in newborn rats, with a 100 mg/kg/day pNOAEL and half the animals dying at 200 mg/kg, compared with a 40 mg/kg/day pNOAEL and only one death in 12 animals at 1000 mg/kg for young rats. Although young rats showed stomach hyperplasia in addition to hepatotoxicity at 1000 mg/kg, the cause of newborn deaths at 200 mg/kg was unclear. With regard to trityl chloride, the pUETL for young rats was almost the same as for newborn although the latter were less susceptible. Such an anomaly has also been found for bromoalkanes previously analyzed. Another example of a chemical for which susceptibility differs at low and high doses is chlorpyrifos, the maximum tolerated dose in 17-day-old rats being reported to be five times less than that in adults following oral exposure (Moser & Padilla 1998), but the differential sensitivity not appearing in low-dose exposure (Pope & Liu 1997). Thus as there are several chemicals of which dose–response curve in newborn rats was obviously steeper than that in young rats, pUETL ratios should be also taken into account for the susceptibility of newborn rats as the second endpoint marker.

In conclusion, newborn rats were 2–5 times more susceptible than young rats in terms of both the pNOAEL and the pUETL in most cases. One exception was that young rats were clearly more susceptible than their newborn counterparts for trityl chloride.

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【短報】

OECD 高生産量化学物質点検プログラム

- 第20回初期評価会議概要 -

OECD High Production Volume Chemicals Programme
- Summary of 20th SIDS Initial　Assessment Meeting -

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要旨：第20回のOECD高生産量化学物質初期評価会議は、2005年4月19日-21日にパリのOECD本部で開催された。この会議では再審議物質2物質を含む計45物質の初期評価文書について審議され、43物質の初期評価結果および評価結果に基づく措置に関する勧告が合意された。日本政府は3物質、2-Furanmethanol, tetrahydro- (CAS:97-99-4)、Phthalimide (CAS:85-41-6)、Sodium nitrite (CAS:7632-00-0)の初期評価文書を提出し、何れも合意された。本稿では、第20回初期評価会議の討議内容の概要を報告する。
キーワード：経済協力開発機構、高生産量化学物質、初期評価会議

Abstract : The 20th SIDS(Screening Information Data Set) Initial Assessment Meeting was held in Paris at OECD headquarters on 19th-21st April 2005. The initial assessment documents of 45 substances were submitted, and 43 were agreed at the meeting. The Japanese Government submitted the initial assessment documents of three substances, 2-furanmethanol, tetrahydro- (CAS:97-99-4), phthalimide (CAS:85-41-6) and sodium nitrite (CAS:7632-00-0), and all three documents were agreed at the meeting. This paper reports the summary record of the 20th SIDS Initial Assessment Meeting.
Keywords: OECD, HPV, SIDS Initial Assessment Meeting

はじめに

　経済協力開発機構（OECD：Organisation for Economic Co-operation and Development）で
は、高生産量化学物質（少なくとも加盟国の１ヶ国において年間 1,000 トンを超えて生産されて
いる化学物質。HPV：High Production Volume Chemical）に対し加盟各国の分担により、安全
性情報を収集・評価する HPV 点検プログラムを行っている。このプログラムは、1990 年の理事
会決定に基づき、化学物質による有害な作用からヒトおよび環境を保護するとともに、各国の化
学物質規制の体制整備・国際協調の場を提供する環境保健安全プログラムの一環として行われて
いる。加盟各国は企業と協力しつつ、それぞれ分担する化学物質の安全性初期評価に必要なスク
リーニング情報データセット（SIDS：Screening Information Data Set）の項目の情報収集や試
験を行い、初期評価プロファイル（SIAP: SIDS Initial Assessment Profile）、初期評価レポー
ト（SIAR: SIDS Initial Assessment Report）および網羅的資料集（Dossier: SIDS Dossier）の
3 文書の初期評価文書を作成し、初期評価会議（SIAM：SIDS Initial Assessment Meeting）で
審議している。1993 年の第 1 回 SIAM から 2000 年 3 月の第 10 回 SIAM までは、加盟国政府が
スポンサーとなり審議を行ってきたが、1998 年秋に国際化学工業協会協議会（ICCA：
International Council of Chemical Association）が HPV 点検プログラムへの参加を表明し、第
11 回 SIAM (2001 年)から ICCA イニシアティブとして評価文書の作成に協力している。
　第 20 回 SIAM は、2005 年 4 月 19 日-21 日にパリの OECD 本部で開催された。加盟国、欧州
委員会および産業界から約 80 名の代表が参加し、再審議物質 2 物質を含む計 45 物質の初期評価
文書について審議を行った。本稿は第 20 回 SIAM での討議内容として、第 19 回 SIAM 以降の
HPV 点検プログラムの進捗状況、初期評価文書の審議結果および本プログラムの全般的な懸案
事項に関する検討結果について報告する。本稿は第 20 回 SIAM の会議報告書（OECD 2005a）
を参照して作成した。
　なお、HPV 点検プログラムを含む OECD の化学物質対策については、長谷川他（1999a）が報告
している。また、日本政府が担当し結論および勧告が合意された化学物質の評価文書についても
長谷川他（1999b、2000、2001）および高橋他（2004、2005a、2005b 印刷中）が報告している。

1．第 19 回 SIAM 以降の HPV 点検プログラム進捗状況

（1）初期評価文書の公開状況
　第 19 回 SIAM（2004 年 10 月）で合意された 56 物質の初期評価文書は、化学物質の安全性に
ついて全般的な方針を決定する OECD の化学品委員会および化学品・農薬・バイオテクノロジ
ー作業部会合同会合（Joint Meeting）で承認され、SIAP が OECD の HPV データベース(OECD
2005b)を通じて公開された。また、国連環境計画(UNEP：United Nations Environment
Programme)は、OECD 事務局から送られた 29 物質の初期評価文書を、2005 年 3 月にウェブサ
イト（UNEP 2005)で公式発表した。これにより、UNEP の累積発表物質数は 207 になった。2005
年 1 月にはさらに 33 物質の初期評価文書が UNEP に送られており、順次公式発表される予定で
ある。
　SIAM における環境影響とヒト健康影響についての勧告は、FW (The substance is a candidate
for further work）または LP (The substance is currently of low priority for further work）と
して示されている。FW は「今後も追加の調査研究作業が必要である」、LP は「現状の使用状
況においては追加作業の必要はない」ことを示す。何れの勧告の場合もその根拠と共に解釈する
ことが望まれており、評価内容と合わせて参照することが期待される。

（２）　HPV 点検プログラムのマニュアル修正

　HPV 点検プログラムのマニュアルの修正は、SIAM での審議結果を反映した OECD 事務局作成の修正草案に対する SIAM の合意および既存化学物質タスクフォース（既存化学物質についての方針決定機関）の承認を得て行われる。

　第 17 回 SIAM（2003 年 11 月）より討議されてきた HPV 点検プログラムのマニュアル修正については、第 19 回 SIAM での合意および既存化学物質タスクフォースの承認をうけ、2004 年 12 月に公式発表された(OECD 2004)。マニュアルの修正箇所は以下の通りである。

　　・Chapter 3、3.1：試験の信頼性を評価する信頼性スコアの使用に関するガイダンス
　　　・加盟各国が共通の理解の基に初期評価文書を作成することを目的とし、信頼性スコアを用いた初期評価文書の作成方法について詳細な規定が加えられた。
　　・Chapter 5：ヒト健康影響と環境影響についてのハザード評価に関するガイダンス
　　　・ヒト健康影響および環境影響に対する化学物質の有害性や暴露の可能性をその程度別に分け、勧告を定める際の基準となるガイダンスが加えられた。
　　・Chapter 2、Annex1：主要研究概要（RSS：Robust Study Summary）のテンプレート
　　　・SIDS 項目以外のエンドポイント（生物濃縮、魚類慢性毒性、神経毒性の試験）に対する RSSのテンプレートが作成されマニュアルに掲載された。

２．第 20 回 SIAM での審議状況

（１）初期評価文書の審議結果

　第20回SIAMでは、再審議2物質を含む計45物質の初期評価文書が審議され、43物質の初期評価結果および勧告が合意された（表1）。

　初期評価文書の審議は、事前に提出された各国の原案に対する会議用掲示板（CDG：Committee Discussion Group）によるオンラインでの討議をもとに修正されたSIAPを中心に行われた。日本政府は新規審議として3物質、2-Furanmethanol, tetrahydro- (CAS:97-99-4)、Phthalimide (CAS:85-41-6)、Sodium nitrite (CAS:7632-00-0)の初期評価文書を提出し、何れも合意が得られた。なお、Phthalimide (CAS:85-41-6)およびSodium nitrite (CAS:7632-00-0)はICCAが原案を作成した。

　ドイツが担当した、Aniline, 3,4-dichloro-(CAS: 95-76-1)の初期評価文書は、第9回SIAM(1999年6月)で審議されたが勧告（環境影響：FW、ヒト健康影響：LP）に合意が得られていなかった。今回の会議では修正した初期評価結果および勧告（環境影響：LP、ヒト健康影響：LP）が合意された。

　物質カテゴリー：Linear alkylbenzene sulfonates (CAS:1322-98-1、25155-30-0、26248-24-8、27636-75-5、68081-81-2、68411-30-3、69669-44-9、85117-50-6、90194-45-9、127184-52-5)(米国/ICCA)の初期評価文書は、第17回SIAMで審議されたが、環境影響のうち水生生物の毒性評価に合意が得られていなかった。第20回SIAMでは、修正した初期評価文書の環境影響に関する評価および勧告に合意が得られた。

　英国/ICCA（環境）は2物質、Tris(2-chloro-1-(chloromethyl)ethyl) phosphate (CAS:13674-87-8) および Phosphoric acid, 2,2-bis(chloromethyl)-1,3- propanediyl tetrakis(2-chloroethyl) (CAS:38051-10-4)の環境影響に関する初期評価文書を提出し、その初期評価結果および勧告が合意された。これら2物質のヒト健康影響に関する初期評価文書は、現在アイルランド共和国が作成中であり将来のSIAMで審議される。

　ベルギー/ICCA は、Phthalic acid, di-C6-8 branched alkyl esters, C7 rich (CAS: 71888-89-6)の初期評価文書で、この物質は水生生物（特に魚類）で生物濃縮しないと結論した。しかし、その試験データの信頼性が低かったことや構造上類似する物質に生物濃縮が認められることから、

生物濃縮の評価について合意が得られなかった。Phthalic acid, di-C6-8 branched alkyl esters, C7 rich (CAS: 71888-89-6)は、水生生物の生物濃縮について信頼性の高い試験結果がないため、構造の類似する Phthalic acid, bis(2-ethylhexyl) ester (CAS:117-81-7)の生物濃縮試験結果をもとに、生物濃縮を検証することとなった。修正した初期評価文書は CDG に掲載され、審議される予定である。

　韓国が提出したBarium carbonate(CAS:513-77-9)の初期評価文書については、生殖発生毒性について信頼性のある試験情報が欠けていたため合意に至らなかった。スポンサー国は、信頼性のある試験情報を集め、主要な試験についてRSSを作成することとなった。修正した初期評価文書をCDGに掲載され、審議される予定である。

（2）HPV 点検プログラムにおける全般的な議題
1）暴露情報の使用について

　暴露情報に関する HPV 点検プログラムのマニュアルについては、第 18 回 SIAM（2004 年 4 月）で、次の 3 項目について修正が必要と結論され、既存化学物質タスクフォースの承認が得られた。

　・現在の HPV 点検プログラムのマニュアルで定められた SIDS 項目で要求される暴露情報の範囲を具体的に規定する。
　・有効な暴露情報の範囲・限度を個々の評価物質の SIAR と SIAP で明瞭化させる。
　・SIAM の勧告は常に暴露情報などの根拠と共に解釈されるものとし、勧告のみを用いて安全性評価を判断させないよう規定する。

　本評価会議に向け、OECD 事務局がこれらの内容を反映した HPV 点検プログラムのマニュアル修正草案を CDG に掲載し、環境 NGO (Environmental Nongovernmental Organization)と米国がコメントを掲載した。第 20 回 SIAM は、環境 NGO と米国のコメントに合意するとともに、主たる生産がスポンサー国にない場合、他国の暴露情報に従って文書作成が出来ることを確認した。また、現在の HPV 点検プログラムのマニュアルに、暴露評価や（必要に応じて）リスク評価を勧告することの意義を明確に記載することおよびその勧告が各加盟国独自のプログラムの設定に役立つことを明らかにする必要があるとした。なお会議は、修正したマニュアル草案を予備的なガイダンスとして使用できるよう、SIDS Contact Points に配布することを OECD 事務局に求めた。したがって、現在準備中の初期評価文書の暴露情報はマニュアル修正草案に基づいて作成されることとなる。暴露情報の扱い方については第 21 回 SIAM において、最終審議が予定されている。

2) (定量的)構造活性相関((Q)SAR: Quantitative Structure-Activity Relationships)アプリケーションツールボックスについて

　OECD における(Q)SAR モデル使用の可能性については、第 34 回 Joint Meeting（2002 年 11 月）より審議され、第 37 回 Joint Meeting（2004 年 11 月）では、(Q)SAR の検証のあり方を定めた OECD 原則（OECD Principles: OECD Principles for the Validation, for Regulatory Purposes, of (Q)SAR）に合意が得られた。

　現在、様々な(Q)SAR モデルが存在するが、それぞれの化学物質に最も適した(Q)SAR モデルを選択するのは容易ではない。また、得られた結果の信頼性を判断するのも難しい状況にある。そこで、第 37 回 Joint Meeting では、使用する(Q)SAR モデルを選択する際や、信頼性を判断する際の基準となる、(Q)SAR アプリケーションツールボックスの開発の必要性が強調された。

　第 20 回 SIAM においては、OECD 事務局が(Q)SAR アプリケーションツールボックスの概念を報告し、今後の(Q)SAR 活用のための計画を提示した。米国は、ツールボックスの開発に関連する様々な問題点を説明し、個々の(Q)SAR の有効性を検証する方法が組織化されるべきである

とコメントした。OECD 事務局は検証方法についての詳細なガイダンスが、OECD Principles に基づいて作成される予定であることを確認した。なお、(Q)SAR の有効性の検証は、OECD の ガイダンスに従って加盟各国またはモデル作成者が行うものとし、どの(Q)SAR モデルを使用す るかも使用者に選択させる予定であると報告した。また、第 20 回 SIAM は、会議出席者の(Q)SAR モデル使用技能を向上させる必要があると結論した。また、(Q)SAR モデルの使用に関してもガ イダンスの作成が必要であるとの指摘があり、OECD 事務局にその作成を要請した。ガイダンス は次の 3 点を考慮し作成されることとなった。

- ・(Q)SAR モデル使用のための検証は、長期的な動物福祉への貢献が予測されるエンドポイン トを用いて行われること。
- ・(Q)SAR モデルの適用性および信頼性を判断するための検証方法や検証用試験データを用意 すること。
- ・(Q)SAR モデル検証の目的を明瞭に記載すること。

3) 物質カテゴリー評価の記載方法について

第 19 回 SIAM では、物質カテゴリーを構成する物質間でデータ参照を行う方法を HPV 点検 プログラムのマニュアルに、ガイダンスとして追加する必要があると結論した。OECD 事務局は ガイダンスの草案を作成し、米国がコメントを提出した。第 20 回 SIAM は、OECD 事務局作成 の草案と米国のコメントに合意すると共に、物質カテゴリーを構成する物質間でデータ参照を行 う際には、カテゴリーの妥当性を確認するために、それぞれの物質の毒性情報を比較する必要が あるとした。これは、SIAR の類似性の根拠を示す項（Analogue justification）に記載すること とし、Dossier に記載する必要はないと結論した。これらの意見を基に OECD 事務局は HPV 点 検プログラムのマニュアルのガイダンスを修正し、承認を受けるため既存化学物質タスクフォー スに提出することとなった。また、OECD 事務局は Dossier を作成する際に使用される IUCLID （International Uniform Chemical Information Database）のガイダンスについても修正草案 を作成することとなった。

4) IBT（Industrial Bio-test）研究所によるデータの取り扱いについて

第 18 回 SIAM では 1976 年に発覚した試験受託機関である IBT 研究所による実験データ捏造 事件を背景に、IBT 研究所の報告書の信頼性をどう判断すべきか、という問題が提起された。 OECD 事務局は、IBT 研究所の試験報告書と生データが監査され、有効性が確認されていない限 り試験情報は無効（invalid）とすべきであると立案していた。しかし第 20 回 SIAM において英 国が代替案を提出した。英国の提案の概要は次の通りである。

- ・EPA（Environmental Protection Agency）/FDA(Food and Drug Administration)による事 後検証プログラムで問題がないと判断された場合は、通常の試験データと同様に扱う。多 少の問題があると示唆された場合は試験データを確認した上使用する。明らかな問題が指 摘される場合は使用しない。
- ・民間による監査の場合、他機関による試験結果と比較し信頼性を判断して使用する。明らか な問題が指摘される場合は使用しない。
- ・試験情報が監査されていない場合、他機関による試験結果と矛盾しないデータは弱い証拠と して使用可能であろうが、矛盾する場合は使用しない。

また、英国は捏造されていた試験項目のリスト（亜急性、亜慢性、発癌性、生殖毒性、催奇形 性、遺伝毒性、神経毒性）を提出するとともに、問題となる期間が特定できる場合は、期間外の 試験結果の使用について、その可能性も審議すべきであるとした。会議は英国の提案に合意し、 OECD 事務局が第 21 回 SIAM に向けて英国の意見を反映したガイダンスの草案を作成すること となった。第 20 回 SIAM の結論として以下の項目について継続的に調査することとなった。

・IBT 研究所の全試験を対象とすべきか、リストにある試験のみとすべきか。また、遺伝毒性試験は問題のある *in vivo* 試験と判断すべきか否か。急性毒性試験については、事後検証プログラムで監査されていないが、それは受け入れ可能な試験結果と判断されたからか、他の試験に比べ関心が低かったからか。

・問題となる試験が行われていた期間を特定することができるか。もし期間が特定できた場合、試験実施期間で考えるべきか、試験責任者による最終報告書への署名時で考えるべきか。

・IBT 研究所の環境に関する試験にも適用できるか否か。

5) 亜鉛の評価法について

オランダと BIAC (Business and Industry Advisory Committee) が亜鉛と亜鉛化合物の評価方法の開発について説明した。開発中の評価法では、水、沈砂、土壌など複数のコンパートメントを用い実際の環境に近い状況を想定し、長期間に渡る金属の運命を予測することが可能となる。過去の SIAM で審議されたカドミウムなどの金属の評価法を例に、その評価方法の違いを示した。亜鉛と亜鉛化合物の初期評価文書については、第 21 回 SIAM で審議される。

6)米国における Extended HPV 点検プログラム

BIAC は、米国のチャレンジプログラム開始後に HPV になった化学物質で、米国のチャレンジプログラムや HPV 点検プログラムの ICCA イニシアティブの対象でない約 500 物質の調査についてイニシアティブを取ることを宣言した。BIAC が作成したそれらの物質についての初期評価文書が将来の SIAM で提出される可能性が示唆された。

おわりに

第 20 回 SIAM では、45 物質の初期評価文書について審議され、日本が提出した 3 物質を含む 43 物質の初期評価結果および評価結果に基づく措置に関する勧告が合意された。勧告の判定については、環境影響またはヒト健康影響に対する有害性が認められ、かつ暴露情報が不足している、または高暴露が予測される物質については FW と結論される傾向にあった。一方、環境影響またはヒト健康影響に対する有害性の低いもの、或いは有害性は認められるが低暴露が予測される物質(ヒト健康影響)および速やかに生分解される物質(環境影響)などは、LP と結論される傾向にあった。第 20 回 SIAM は、初期評価文書の審議のほか、過去の SIAM からの懸案事項である暴露情報の扱い方、物質カテゴリー評価の記載方法、IBT 研究所の試験データの取り扱い方などについても審議された。これらについては、第 21 回 SIAM でも討議される予定であり、特に IBT 研究所の試験データの取り扱いについては、今後も情報収集を続けることとされた。また、新しい議題として(Q)SAR アプリケーションツールボックスの開発について討議された。

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表 1　第 20 回 SIAM で審議された化学物質と合意結果

CAS No.	化学物質名／物質カテゴリー名	スポンサー	勧告	
			環境	ヒト健康
1322-98-1	Benzenesulfonic acid, decyl-, Na salt	US/ICCA	LP	LP
25155-30-0	Benzenesulfonic acid, dodecyl-, Na salt			
26248-24-8	Benzenesulfonic acid, tridecyl-, Na salt			
27636-75-5	Benzenesulfonic acid, undecyl-, Na salt			
68081-81-2	Benzenesulfonic acid, mono-C10-16-alkyl			
68411-30-3	Benzenesulfonic acid, C10-13-alkyl deriv			
69669-44-9	C10-14 Alkyl deriv benzene sulfonic acid, sodium salt			
85117-50-6	Benzenesulfonic acid, mono-C10-14-alkyl			
90194-45-9	Benzenesulfonic acid, mono-C10-13-alkyl deriv, sodium salts			
127184-52-5	4-C10-13-sec Alkyl deriv benzene sulfonic acid, sodium salt / Linear alkylbenzene sulfonates			
95-76-1	Aniline, 3,4-dichloro-	DE:eu	LP	LP
60-24-2	Ethanol, 2-mercapto-	DE/ICCA	LP	LP
97-99-4	2-Furanmethanol, tetrahydro-	JP	LP	FW
79-77-6	3-Buten-2-one,4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-	DE/ICCA	LP	LP
106-43-4	Toluene, 4-chloro-	DE/ICCA	LP	FW
79-94-7	Tetrabromo bisphenol A	UK:eu	FW	LP
85-41-6	Phthalimide	JP/ICCA	LP	LP
85-44-9	1,3-Isobenzofurandione	DE/ICCA	LP	FW
108-21-4	Isopropyl acetate	US/ICCA	LP	LP
97-85-8	Isobutyl isobutyrate	US/ICCA	LP	LP
71888-89-6	Phthalic acid, di-C6-8 branched alkyl esters C7 rich	BE/ICCA	LP	FW
117-81-7	Phthalic acid, bis(2-ethylhexyl) ester	SE:eu	FW	FW
78-79-5	Isoprene	US/ICCA	LP	LP
354-33-6	Ethane, pentafluoro-	US/ICCA	LP	LP
68390-56-7	Fatty acids, tallow, hydrogenated, dimers, diketene derivs	UK/ICCA	LP	LP
84989-41-3	2-Oxetanone, 3-C12-16-alkyl-4-C13-17-alkylidene derives / Alkyl ketene dimers			
105-53-3	Diethyl malonate	DE/ICCA	LP	LP
108-59-8	Dimethyl malonate / Malonates			
1328-53-6	C.I. Pigment Green 7	DE/ICCA	LP	LP
70942-01-7	Potassium sodium 4,4'-bis[6-anilino-4-[bis(2-hydroxyethyl)amino]-1,3,5-triazin-2-yl]amino]stilbene-2,2'-disulphonate	DE/ICCA	LP	LP
71230-67-6[a)	Benzenesulfonic acid, 2-2'-(1,2-ethenediyl) bis(5-((4-(bis(2-hydroxyethyl)amino)-6- (phenylamino) -1,3,5-triazin-2-yl)amino) -, dipotassium salt			