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# Safety Assessment of Alkyl Betaines

## as Used in Cosmetics

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*All interested persons are provided 60 days from the above date to comment on this Scientific Literature Review and to identify additional published data that should be included or provide unpublished data which can be made public and included. Information may be submitted without identifying the source or the trade name of the cosmetic product containing the ingredient. All unpublished data submitted to CIR will be discussed in open meetings, will be available at the CIR office for review by any interested party and may be cited in a peer-reviewed scientific journal. Please submit data, comments, or requests to the CIR Director, Dr. F. Alan Andersen.*

The 2013 Cosmetic Ingredient Review Expert Panel members are: Chairman, Wilma F. Bergfeld, M.D., F.A.C.P.; Donald V. Belsito, M.D.; Curtis D. Klaassen, Ph.D.; Daniel C. Liebler, Ph.D.; Ronald A. Hill, Ph.D. James G. Marks, Jr., M.D.; Ronald C. Shank, Ph.D.; Thomas J. Slaga, Ph.D.; and Paul W. Snyder, D.V.M., Ph.D. The CIR Director is F. Alan Andersen, Ph.D. This safety assessment was prepared by Christina L. Burnett, Scientific Analyst/Writer, and Bart Heldreth, Ph.D., Chemist CIR.

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1101 17<sup>th</sup> Street, NW, Suite 412 ♦ Washington, DC 20036-4702 ♦ ph 202.331.0651 ♦ fax 202.331.0088 ♦  
cirinfo@cir-safety.org

## **INTRODUCTION**

This safety assessment addresses the safety of 11 alkyl betaines as used in cosmetics. The parent compound, betaine, is a naturally occurring N-trimethylated amino acid, also called trimethylglycine, and can be isolated from sugar beets.<sup>1</sup> It is a common component in the human diet. These cosmetic ingredients mainly function as antistatic agents, hair conditioning agents, skin-conditioning agents, surfactants-cleansing agents, and viscosity increasing agents in cosmetic products.<sup>2</sup> CIR recently has reviewed the safety of cocamidopropyl betaine and related amidopropyl betaines as used in cosmetics.<sup>3</sup>

## **CHEMISTRY**

The definitions of the 11 alkyl betaines in this safety assessment can be found in Table 1, and formulas and idealized structures of these ingredients can be found in Figure 1.

The alkyl betaines are zwitterionic ingredients comprised of tertiary ammonium substituted acetate. These ingredients have a core structure of 2-(alkyldimethylammonio)acetate (i.e., *N,N,N*-trisubstituted glycine). Therein, the “alkyl” is either methyl, as in the case of betaine itself, or an actual alkyl group ranging in length from about ten (e.g., decyl betaine) to about twenty-two (e.g., behenyl betaine) carbons. Ten to twenty-two carbons are an estimate, however, as the compositions of the ingredients derived from plant and animal sources (e.g., coco-betaine, tallow betaine, and hydrogenated tallow betaine) are variable.

The zwitterionic structure of these ingredients makes them amphoteric, a hallmark characteristic of some classical surfactants. The fatty chains, found on most of these ingredients, add a lipophilic tail to these hydrophilic head groups, further imparting surfactant properties. Most of these ingredients are colorless, crystalline materials with good solubility in water and polar organic solvents.

### **Physical and Chemical Properties**

Available chemical properties can be found in Table 2.

## **USE**

### **Cosmetic**

Table 3 presents the current product-formulation data for alkyl betaines. These cosmetic ingredients mainly function as antistatic agents, hair conditioning agents, skin-conditioning agents, surfactants-cleansing agents, and viscosity increasing agents in cosmetic products.<sup>2</sup> According to information supplied to the Food and Drug Administration (FDA) by industry as part of the Voluntary Cosmetic Registration Program (VCRP), betaine has the most reported uses in cosmetic and personal care products, with a total of 459; the majority of the uses are in leave-on skin care preparations.<sup>4</sup> Lauryl betaine has the second greatest number of overall uses reported, with a total of 338; the majority those uses are in rinse-off personal cleanliness products. The 8 ingredients with reported VCRP uses are:

- betaine
- behenyl betaine
- cetyl betaine
- coco-betaine
- lauryl betaine
- myristyl betaine
- oleyl betaine and
- stearyl betaine

Three ingredients are included in this safety assessment for which no uses have been reported to the VCRP:

- decyl betaine
- hydrogenated tallow betaine and
- tallow betaine

A survey of the concentration of use of these ingredients is currently being conducted by the Personal Care Products Council.

Alkyl betaines are not restricted from use in any way under the rules governing cosmetic products in the European Union.<sup>5</sup>

### **Non Cosmetic**

A biocide that contains cetyl betaine is currently being studied as a preventative treatment of human immunodeficiency virus type 1 (HIV-1) and other sexually transmitted diseases in vaginal microbicides and contraceptives.<sup>6,7</sup>

Betaine hydrochloride has been approved by the FDA to treat homocystinuria (by reducing homocysteine levels).<sup>8</sup> It is also present as an active ingredient in over-the-counter digestive aids, however, FDA has determined that there are inadequate data to establish general recognition of the safety and effectiveness of the ingredient for these specified uses (21 CFR §310.545).

## **TOXICOKINETICS**

### **Absorption, Distribution, Metabolism, and Excretion**

#### **Betaine**

The pharmacokinetics and acute effects on plasma total homocysteine (tHcy) of orally administered betaine (see use of betaine hydrochloride in treating homocystinuria above) was assessed in healthy human volunteers (3 men and 7 women).<sup>9</sup> Information on the absorption and elimination of betaine was also developed. In a double-blind crossover, each subject ingested the betaine in doses of 1, 3, and 6 g mixed with 150 ml orange juice. The doses were ingested 7 days apart following a 12-h overnight fast. Blood samples for serum betaine concentration measurement were drawn just before receiving the betaine dose, at 20-min intervals during the first 3 h, and then at 4-, 7-, and 24-h post dosing. Urine samples were collected before dosing and during the 24-h follow-up period. Within 2 h, a dose-dependent effect on serum betaine concentration was observed. Absorption and elimination of betaine were dose dependent, with urinary excretion of betaine increasing with betaine dose. Only a very small proportion of the ingested betaine was excreted in urine, however, with 3.2%, 4.3%, and 7.4% of the 1, 3, and 6 g doses accounted for, respectively.

#### **Cetyl Betaine and Lauryl Betaine**

The absorption of radiolabeled cetyl betaine and lauryl betaine was determined using diffusion cells containing excised hairless mouse skin.<sup>10</sup> Lauryl betaine was well absorbed while cetyl betaine partitioned into the skin but slowed transfer to the receptor phase. This study also examined the effects of cetyl betaine and lauryl betaine on skin barrier function in hairless mouse skin in vitro. Excised skin was pretreated with each test material for 16 h, at concentrations up to 5.4 mM for cetyl betaine and 16 mM for lauryl. After pretreatment, the permeation of the model compound, nicotinamide, across membranes was measured and the results were compared to the flux across control membranes that were exposed to buffer alone. All surfactants decreased skin barrier function to some extent. The degree of nicotinamide penetration enhancement induced was correlated with the ratio of the surfactant pretreatment concentration to the surfactant critical micelle concentration. The authors of the study suggested that solubilization of stratum corneum lipids may be an important mechanism in explaining the effects observed.

The dermal uptake of cetyl betaine and lauryl betaine was measured in vivo with human skin.<sup>11</sup> Male volunteers received <sup>14</sup>C-radiolabeled test materials in aqueous solution on the dorsal upper arm for 30 min. The concentrations of cetyl betaine and lauryl betaine applied were 0.14, 1.0, and 5.4 mM and 16, 100, and 800 mM, respectively. The positive control was 50 mM caffeine. At the end of the exposure period, the remaining test materials were rinsed from the skin and the skin was washed. The stratum corneum at the test sites were removed with repeated tape-stripping. Dermal uptake was assessed by measuring the recovered radioactivity from the tape strips and compared to predicted penetration values. The measured uptake of cetyl betaine and lauryl betaine was 28-160 nmol/cm<sup>2</sup> and 2.3-19.5 nmol/cm<sup>2</sup>, respectively. The predicted penetration values were 51-292 nmol/cm<sup>2</sup> for cetyl betaine and 3.7-35 nmol/cm<sup>2</sup>. Caffeine penetrated at expected amounts. The tape stripping indicated that the radiolabel was mostly found in the outer layers of the stratum corneum.

The same study also assessed skin barrier function.<sup>11</sup> Non-radiolabeled cetyl betaine and lauryl betaine were applied to the skin for 30 min. The transepidermal water loss (TEWL) was assessed. No changes in TEWL values were observed after treatment of the skin with the betaines or with saline controls.

## **TOXICOLOGICAL STUDIES**

### **Acute Toxicity**

#### **Oral – Non-Human**

##### **Betaine**

The oral LD<sub>50</sub> value of betaine in rats has been reported to be around 11.179 g/kg bodyweight. The study was performed in accordance to OECD guideline 401 (no further details provided).<sup>12</sup>

### **Cetyl Betaine and Lauryl Betaine**

The oral LD<sub>50</sub> values were reported to be 1620 mg/kg for cetyl betaine and 71 mg/g for lauryl betaine.<sup>10</sup> Groups of 5 male Sprague-Dawley rats received cetyl betaine (94.9% pure) or lauryl betaine (98.9% pure) via oral gavage. The doses were not reported, but the rats received the test substances in 25% w/v solutions. Sluggishness, diarrhea, and lacrimation were observed in some animals that received either test material. Weight gains were within normal parameters in surviving animals. Gross necropsy of the animals that died during the study (number not reported) found the gastrointestinal tract was distended with red fluid and the lungs appeared mottled and red. There were no significant differences in the pharmacotoxic signs or gross necropsy findings between the 2 test materials.

### **Dermal – Non-Human**

#### **Cetyl Betaine and Lauryl Betaine**

The LD<sub>50</sub> values were greater than 16 g/kg for cetyl betaine and 1.3 g/kg for lauryl betaine.<sup>10</sup> Groups of 5 male Sprague-Dawley rats received cetyl betaine (94.9% pure) or lauryl betaine (98.9% pure) dermally on clipped trunks. The doses were not reported. The test sites were occluded for 24 h, after which the test sites were wiped clean of the test materials. Erythema, edema, desquamation, necrosis, and scab formation were observed on the test sites for both test materials, as was sluggishness and reddish nasal and ocular discharges. Body weight gains were within normal parameters. No treatment-related changes due to either test material were observed at gross necropsy.

### **Other Exposures – Non-Human**

#### **Betaine**

The intravenous LD<sub>50</sub> value of betaine in mice has been reported to be 830 mg/kg bodyweight (no further details provided).<sup>12</sup>

#### **Cetyl Betaine and Lauryl Betaine**

Groups of 5 male Sprague-Dawley rats received cetyl betaine (94.9% pure) or lauryl betaine (98.9% pure) intraperitoneally.<sup>10</sup> The doses were not reported, but the rats received the test substances in 5% or 25% w/v solutions in distilled water. Sluggishness, diarrhea, lacrimation, and distended abdomen were observed in animals that received either test material. Body weight gains were within normal parameters. No treatment-related changes due to either test material were observed at gross necropsy. The LD<sub>50</sub> values were 150 mg/kg for cetyl betaine and 53 mg/kg for lauryl betaine.

## **Repeated Dose Toxicity**

### **Oral – Human**

#### **Betaine**

The effects of betaine supplementation on body weight, body composition, plasma homocysteine concentrations, blood pressure, and serum total and lipoprotein lipids was studied in 42 obese, white subjects (14 males, 28 females).<sup>13</sup> The subjects were randomly assigned to either a placebo group or a betaine-supplemented group that received 6 g of betaine daily for 12 weeks. The intervention period was preceded by a 4-week run-in period with a euenergetic diet and the subjects received a hypoenergetic diet during betaine treatment. No adverse side effects were observed in any of the subjects in the treatment group or the placebo group. When compared to the placebo group, there were no significant differences in decreases of body weight, resting energy expenditure, or fat mass. A decrease in diastolic blood pressure was similar in both groups. A decrease in plasma homocysteine concentration was observed in the betaine group with concentrations measuring at approximately 8.76 μmol/L at 4 weeks and 7.93 μmol/L at 16 weeks ( $P = 0.030$ ). Serum total and LDL-cholesterol concentrations were higher in the betaine group than in the control group ( $P < 0.05$ ). The authors concluded that hypoenergetic diets supplemented with betaine decreased plasma homocysteine concentrations more than diets without betaine supplementation. The supplemented diets did not affect body composition.

## **REPRODUCTIVE AND DEVELOPMENTAL TOXICITY**

### **Cetyl Betaine**

The developmental toxicity/teratogenicity of cetyl betaine was studied dermally in female New Zealand White rabbits.<sup>14,15</sup> Groups of 8 artificially inseminated rabbits received 0, 10, 20, 40, 100, or 200 mg/kg/day of the test material in 5% isopropanol in dosage volumes of 2 ml/kg. The rabbits received the test material for 4 hours daily on approximately days 6 through 18 of gestation. Test substance-related mortality and severe topical effects occurred in the 100 and 200 mg/kg dose groups after the eighth and sixth dosages, respectively, and administration

of these dose levels was discontinued. Two additional test groups in non-inseminated rabbits were added: one received a new vehicle control (not reported) and the other received 2 mg/kg/day of the test material in the new vehicle control. All animals were observed daily for signs of toxicity, skin irritation, abortion (inseminated rabbits), death, body weight and feed consumption. Rabbits that died during the study were examined for pregnancy (inseminated rabbits) and cause of death. The inseminated rabbits were killed on day 19 of gestation and the non-inseminated rabbits were killed 24 h after the 13<sup>th</sup> daily dosage was administered. Inseminated rabbits underwent a complete gross necropsy, including examination of the brain, uterus, and fetuses.

In the 100 and 200 mg/kg dose groups, 3 rabbits each died or were killed during the course of the study. Clinical observations in these groups and the 40 mg/kg dose group included uncoordinated movement, partial paralysis, red exudate of vaginal origin present in the cage pan, green matter fur, ataxia, and alopecia. All skin reactions, including erythema, desquamation, atonia, fissuring, eschar and exfoliation were dose-dependent. All rabbits in each dose group had a minimum of grade 1 erythema observed at least once. No rabbits in any dose group had edema. When compared to the control group, average body weight gain was inhibited in rabbits of the 2 through 200 mg/kg dose groups and was considered to be dose dependent. The severity of the effect was slight in the 2 and 10 mg/kg dose groups and marked in the 100 and 200 mg/kg dose groups. Decreased average daily feed consumption was noted in the 2 through 200 mg/kg dose groups and was also considered to be dose dependent. It was considered biologically significant in the 40 to 200 mg/kg dose groups. Pregnancy was observed in 6 or 7 of the 8 rabbits in each dose group. An increased incidence of resorptions was observed in the materially toxic doses of 40, 100, and 200 mg/kg/day. A decrease in average litter size was observed in the 100 and 200 mg/kg dose groups. All fetuses were alive at Caesarean-sectioning, but were not examined. The results determined that doses of 0, 2, 10, and 20 mg/kg would be used in a definitive rabbit teratology study (results of this study have not been found). The maternal LOAEL was determined to be 10 mg/kg/day and a maternal NOAEL could not be established. The developmental LOAEL was 40 mg/kg/day and the developmental NOAEL was 20 mg/kg/day.<sup>14,15</sup>

In an oral developmental toxicity/teratogenicity study, female rats (species not reported) received 0, 50, 150, and 250 mg/kg/day of 30.4% active cetyl betaine in 10% ethanol (correction factor of 3.2895 was utilized to achieve proper amount of active ingredient).<sup>14,15</sup> The control group received ethanol in deionized water at a volume of 5 ml/kg, which was the same amount of ethanol that the 250 mg/kg dose group received. The rats received the test material daily for 10 days starting on gestation day 6. The animals were observed twice daily for signs of toxicity and body weights and feed consumption were recorded on day 0, 6, 9, 12, 16, and 20 of gestation. On gestation day 20, all surviving rats were killed and the uterus and the fetuses were examined and measured for number and location of viable and nonviable fetuses, early and late resorptions, number of total implantations and corpora lutea, fetal body weights, sex, external malformations or developmental variations, and skeletal abnormalities.

No mortalities were observed in any of the dams in the control or treatment groups. In the 250 mg/kg dose group, clinical observations included stained and matted fur primarily on the limbs, neck, ventral thorax, and facial area, excessive salivation, respiratory rales, diarrhea, decreased activity, hypothermia, lacrimation, labored breathing, and wheezing. Similar observations were made in the 150 mg/kg dose group, with the stained and matted fur and respiratory rales the predominant signs of toxicity. A dose-related trend of maternal body weight inhibition was observed during overall gestation and the treatment periods at all dose levels. Weight loss was observed during the first treatment interval in the 150 and 250 mg/kg dose groups. Decreased feed consumption was also observed in all treated groups during the treatment period in a dose-dependent manner. Feed consumption was noted to be inhibited at 250 mg/kg during the overall gestation period, but the mean values for the 50 and 150 mg/kg dose groups were comparable to controls. No treatment-related effects were noted in the dams in any dose group. In the fetuses, no significant differences between the control and treated groups were evident with respect to number of corpora lutea, total implantations, post implantation loss, viable fetuses, and fetal body weights. Fetal malformation in the treated groups was not significantly different from that of the controls. Reduced or absent ossification of the skull, sternebrae #5 and/or #6, and other sternebrae occurred more frequently in the 250 mg/kg dose group. These effects were considered to be biologically significant as they were observed in conjunction with reduced maternal body weights. No other developmental variations were noted. The LOAEL for the dams was 50 mg/kg. A maternal NOAEL could not be calculated. For cetyl betaine, the developmental LOAEL was 250 mg/kg and the developmental NOAEL was 150 mg/kg.<sup>14,15</sup>

## GENOTOXICITY

### In Vitro

#### **Betaine**

Betaine monohydrate was tested for genetic toxicity in a bacterial reverse mutation assay using *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537, and TA1538. The strains were plated with betaine at concentrations of 8 to 5000 µg/plate, with and without S-9 metabolic activation. The results were negative for genotoxicity (no further details were provided).<sup>12</sup>

Betaine monohydrate at concentrations up to 10 mg/ml was not clastogenic in a study using human lymphocytes in whole blood cultures (no further details were provided).<sup>12</sup>

### **In Vivo**

#### **Betaine**

The genotoxicity of betaine monohydrate was studied in a micronucleus assay using male and female CD-1 mice. The mice received 0, 0.5, 1, or 2 g/kg of the test material or the positive control cyclophosphamid by gavage. Exposure periods were 24, 48, or 72 h. Betaine monohydrate did not induce micronuclei in the bone marrow of the mice dosed up to 2 g/kg (no further details were provided).<sup>12</sup>

## **IRRITATION AND SENSITIZATION**

### **Irritation and Anti-Irritation**

#### ***Dermal - Human***

##### **Betaine**

The efficacy of betaine to reduce irritation in soap was assessed in 2 studies with healthy subjects (n=28 and n=21).<sup>1,16</sup> The soap containing betaine (tested up to 10%) was found to be less irritating than those without the test material, but not in a dose-dependent manner.

##### **Coco-Betaine**

The potential of 4 surfactants, including coco-betaine, to cause dermal irritation was assessed in a TEWL study with Finn chambers in 27 healthy volunteers.<sup>17</sup> The subjects were exposed to the test substances and controls for 24 h. Sodium lauryl sulfate (SLS) had the greatest mean TEWL (15.5 g/m<sup>2</sup>h), followed by coco-betaine (12.6 g/m<sup>2</sup>h), sodium laurate (10.6 g/m<sup>2</sup>h), and polysorbate-60 (9.8 g/m<sup>2</sup>h). No severe reactions (3+ or 4+) were observed following the exposure to 2 g/100 ml of the test substances. Coco-betaine had less irritation potential than SLS.

#### ***Ocular – Non-Human***

##### **Betaine**

In a study performed in rabbits per OECD guideline 405, betaine monohydrate was not irritating to the eye (no further details were provided).<sup>12</sup>

#### ***Mucosal - Human***

##### **Betaine**

In a study of the effects of betaine to reduce mucosal irritation in toothpastes containing SLS in 20 subjects, toothpaste containing 4% betaine alone did not irritate the mucosa in vivo.<sup>18</sup> The subjects were exposed to the test materials on buccal mucosa with a test chamber kept in place for 15 min. Irritation was assessed visually and with electrical impedance for up to 45 min. Toothpastes that contained SLS were observed to have irritating effects on the oral mucosa.

In a similar study testing the efficacy of betaine to reduce “dry mouth” in toothpaste with SLS, 13 subjects did not experience any adverse effects to toothpaste containing 4% betaine.<sup>19</sup>

### **Sensitization**

#### ***Dermal – Non-Human***

##### **Betaine**

In a guinea pig maximization study per OECD guideline 406, betaine monohydrate was not sensitizing (no further details were provided).<sup>12</sup>

## **CLINICAL USE**

### **Case Reports**

#### **Coco Betaine**

Two cases of eczematous lesions were reported following exposure to shampoos containing coco betaine.<sup>20</sup> In the first case, a 44-year old woman presented with acute eczematous lesions with erythema, edema, and

vesiculation on the backs and palms of her hands a few days after using a shampoo with chestnut leaf extract. Her scalp also itched and was slightly red. Previous patch tests showed positive reactions to PPD, benzocaine, wool alcohols, parabens, chinosform, perfumes, nickel sulfate, and cobalt chloride. Patch tests with the shampoo and individual components showed a ++ reaction to the shampoo in open test as is and in patch test at 2% aq., ++ reaction to parahydroxybenzoic acid esters (5% pet.), and +++ reaction to coco betaine (2% aq.). No reactions were observed to the perfume component. The dermatitis cleared when the patient changed shampoos.

In the second case, a 22-year old woman presented with red, swollen face and weeping eczematous lesions. Red, oozing and crusted acute lesions were also observed on her shoulders and scalp. The symptoms occurred after using a new shampoo. Patch tests with the shampoo and the individual components showed a +++ reaction to the shampoo in open test as is and in patch test at 2% aq., ++ reaction to coco betaine (2% aq.), and ++ reaction to sodium lauryl ether sulfate (2% aq.). The symptoms cleared when the patient changed shampoos.<sup>20</sup>

### SUMMARY

The alkyl betaines are zwitterionic ingredients comprised of tertiary ammonium substituted acetate. These cosmetic ingredients mainly function as antistatic agents, hair conditioning agents, skin-conditioning agents, surfactants-cleansing agents, and viscosity increasing agents in cosmetic products. According to information supplied to FDA's VCRP, betaine has the most reported uses in cosmetic and personal care products, with a total of 459; the majority of the uses are in leave-on skin care preparations. Lauryl betaine has the second greatest number of overall uses reported, with a total of 338; the majority those uses are in rinse-off personal cleanliness products. A survey of the concentration of use of these ingredients is currently being conducted by the Personal Care Products Council.

Absorption and elimination of betaine were dose dependent, with urinary excretion of betaine increasing with betaine dose.

Cetyl betaine and lauryl betaine were observed to decrease skin barrier function in hairless mouse skin in vitro. Cetyl betaine and lauryl betaine absorbed into mouse skin in vitro, with lauryl betaine absorbing at a faster rate. Dermal penetration rates for cetyl betaine and lauryl betaine were measured in vivo with human skin.

The oral LD<sub>50</sub> value of betaine in rats has been reported to be around 11.179 g/kg bodyweight while the oral LD<sub>50</sub> values were reported to be 1620 mg/kg for cetyl betaine and 71 mg/g for lauryl betaine in rats. Also in rats, the dermal LD<sub>50</sub> values were greater than 16 g/kg for cetyl betaine and 1.3 g/kg for lauryl betaine. The intravenous LD<sub>50</sub> value of betaine in mice has been reported to be 830 mg/kg bodyweight. The LD<sub>50</sub> values were 150 mg/kg for cetyl betaine and 53 mg/kg for lauryl betaine in an intraperitoneal study in rats.

In repeated dose toxicity studies in obese humans, no adverse side effects were observed in any of the subjects that received 6 g of betaine/day.

Dermal reproductive and developmental toxicity studies of cetyl betaine in rabbits determined the maternal LOAEL to be 10 mg/kg/day and a maternal NOAEL could not be established. The developmental LOAEL was 40 mg/kg/day and the developmental NOAEL was 20 mg/kg/day. In oral reproductive and developmental toxicity studies of cetyl betaine in rats, the LOAEL for the dams was 50 mg/kg and a maternal NOAEL could not be calculated. The developmental LOAEL was 250 mg/kg and the developmental NOAEL was 150 mg/kg.<sup>14,15</sup>

Betaine monohydrate was not genotoxic in in vitro or in vivo studies.

In ocular studies of rabbit eyes, betaine monohydrate was not irritating. Betaine did not cause adverse effects in human mucosal studies. Betaine monohydrate was not sensitizing in a guinea pig maximization study.

Allergic reactions to coco-betaine have been reported in case studies.

## FIGURES

**Figure 1.** Formulas and idealized structures of the ingredients in this safety assessment.

Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Behenyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_{20}\text{CH}_2 - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Cetyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_{14}\text{CH}_2 - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Coco-Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{R} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$ <p style="text-align: center;">where R represents the alkyl groups derived from coconut oil.</p>
Decyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_8\text{CH}_2 - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Hydrogenated Tallow Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{R} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$ <p style="text-align: center;">where R represents the alkyl groups derived from hydrogenated tallow.</p>
Lauryl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_{11} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Myristyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_{13} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Oleyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_6 - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Stearyl Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3(\text{CH}_2)_{17} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$
Tallow Betaine	$\begin{array}{c} \text{CH}_3 \\   \\ \text{R} - \text{N}^+ - \text{CH}_2\text{COO}^- \\   \\ \text{CH}_3 \end{array}$ <p style="text-align: center;">where R represents the alkyl groups derived from tallow.</p>

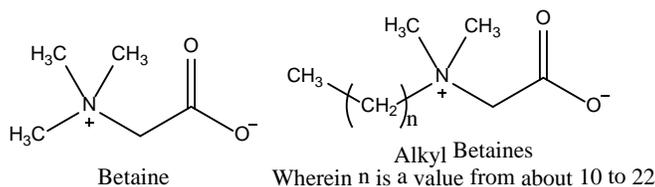


Figure 2. Betaine and the Alkyl Betaines

## TABLES

**Table 1.** Definitions and functions of the ingredients in this safety assessment.<sup>2</sup> (The italicized text below represents additions made by CIR staff.)

<b>Ingredient/CAS No.</b>	<b>Definition</b>	<b>Function</b>
Betaine 107-43-7	Betaine is the zwitterion (inner salt) that conforms to the formula. <i>Betaine is the N,N,N-trimethylammonium zwitterion of glycine.</i>	Hair conditioning agents; humectants; skin-conditioning agents-humectants
Behenyl Betaine	Behenyl Betaine is the zwitterion (inner salt) that conforms to the formula. <i>Behenyl Betaine is the N-behenyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Cetyl Betaine 693-33-4	Cetyl Betaine is the zwitterion (inner salt) that conforms to the formula. <i>Cetyl Betaine is the N-cetyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Coco-Betaine 68424-94-2	Coco-Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Coco-Betaine is the N-cocyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Decyl Betaine 2644-45-3	Decyl Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Decyl Betaine is the N-decyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Hydrogenated Tallow Betaine	Hydrogenated Tallow Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Hydrogenated Tallow Betaine is the ammonium zwitterion of glycine, wherein nitrogen is substituted with two methyl groups and an fatty chain derived from hydrogenated tallow.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Lauryl Betaine 683-10-3	Lauryl Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Lauryl Betaine is the N-lauryl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Myristyl Betaine 2601-33-4	Myristyl Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Myristyl Betaine is the N-myristyl-N,N-dimethylammonium zwitterion of glycine.</i>	Abrasives; antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Oleyl Betaine 871-37-4	Oleyl Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Oleyl Betaine is the N-oleyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Stearyl Betaine 820-66-6	Stearyl Betaine is the zwitterion (inner salt) that conforms to the formula. <i>Stearyl Betaine is the N-stearyl-N,N-dimethylammonium zwitterion of glycine.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous
Tallow Betaine	Tallow Betaine is the zwitterion (inner salt) that conforms generally to the formula. <i>Tallow Betaine is the ammonium zwitterion of glycine, wherein nitrogen is substituted with two methyl groups and an fatty chain derived from tallow.</i>	Antistatic agents; hair conditioning agents; skin-conditioning agents-misc.; surfactants-cleansing agents; surfactants-foam boosters; viscosity increasing agents-aqueous

**Table 2.** Physical and chemical properties.

	<b>Property</b>	<b>Reference</b>
<b><i>Betaine</i></b>		
Physical Form	Deliquescent scales or prisms	<sup>21</sup>
Molecular Weight	117.15	<sup>12,21</sup>
Melting Point	293 (decomposes)	<sup>12</sup>
Water Solubility g/L	160	<sup>21</sup>
Other Solubility g/L	55 in methanol, 8.7 in ethanol, sparingly sol in ether	<sup>21</sup>
<b><i>Cetyl Betaine</i></b>		
Vapor pressure mmHg@ 25 °C	$2.4 \times 10^{-12}$	<sup>14</sup>
Melting Point °C	243	<sup>14</sup>
Boiling Point °C @ 760 mmHg	566	<sup>14</sup>
Water Solubility mg/L @ 25 °C	171	<sup>14</sup>
log K <sub>ow</sub>	2.44	<sup>14</sup>
<b><i>Lauryl Betaine</i></b>		
Physical Form	Crystals or colorless needles	<sup>21</sup>
Molecular Weight g/mol	271.44	<sup>21</sup>
Melting Point °C	183-185	<sup>21</sup>
Water Solubility	Easily soluble in water	<sup>21</sup>
Other Solubility	Easily soluble in methanol, ethanol, and benzene; moderately soluble in acetone	<sup>21</sup>
Disassociation constants (pKa)	1.8	<sup>21</sup>

**Table 3.** Frequency and concentration of use (2013) according to duration and type of exposure for alkyl betaines.<sup>4</sup>

	<i># of Uses</i>	<i>Max Conc of Use (%)</i>	<i># of Uses</i>	<i>Max Conc of Use (%)</i>	<i># of Uses</i>	<i>Max Conc of Use (%)</i>
	<b>Behenyl Betaine</b>		<b>Betaine</b>		<b>Cetyl Betaine</b>	
<b>Totals*</b>	<b>4</b>	<b>NR</b>	<b>459</b>	<b>NR</b>	<b>14</b>	<b>NR</b>
<b><i>Duration of Use</i></b>						
Leave-On	1	NR	326	NR	NR	NR
Rinse-Off	3	NR	130	NR	14	NR
Diluted for (Bath) Use	NR	NR	3	NR	NR	NR
<b><i>Exposure Type</i></b>						
Eye Area	NR	NR	31	NR	NR	NR
Incidental Ingestion	NR	NR	6	NR	NR	NR
Incidental Inhalation-Spray	NR	NR	4	NR	NR	NR
Incidental Inhalation-Powder	NR	NR	4	NR	NR	NR
Dermal Contact	4	NR	379	NR	12	NR
Deodorant (underarm)	NR	NR	NR	NR	NR	NR
Hair - Non-Coloring	NR	NR	50	NR	2	NR
Hair-Coloring	NR	NR	22	NR	NR	NR
Nail	NR	NR	NR	NR	NR	NR
Mucous Membrane	NR	NR	19	NR	6	NR
Baby Products	NR	NR	4	NR	NR	NR
	<b>Coco-Betaine</b>		<b>Lauryl Betaine</b>		<b>Myristyl Betaine</b>	
<b>Totals*</b>	<b>227</b>	<b>NR</b>	<b>338</b>	<b>NR</b>	<b>6</b>	<b>NR</b>
<b><i>Duration of Use</i></b>						
Leave-On	4	NR	29	NR	NR	NR
Rinse Off	213	NR	281	NR	6	NR
Diluted for (Bath) Use	10	NR	28	NR	NR	NR
<b><i>Exposure Type</i></b>						
Eye Area	1	NR	2	NR	NR	NR
Incidental Ingestion	NR	NR	NR	NR	NR	NR
Incidental Inhalation-Spray	NR	NR	1	NR	NR	NR
Incidental Inhalation-Powder	NR	NR	NR	NR	NR	NR
Dermal Contact	141	NR	308	NR	6	NR
Deodorant (underarm)	NR	NR	NR	NR	NR	NR
Hair - Non-Coloring	70	NR	29	NR	NR	NR
Hair-Coloring	16	NR	1	NR	NR	NR
Nail	NR	NR	NR	NR	NR	NR
Mucous Membrane	87	NR	262	NR	6	NR
Baby Products	3	NR	1	NR	NR	NR
	<b>Oleyl Betaine</b>		<b>Stearyl Betaine</b>			
<b>Totals*</b>	<b>5</b>	<b>NR</b>	<b>1</b>	<b>NR</b>		
<b><i>Duration of Use</i></b>						
Leave-On	NR	NR	1	NR		
Rinse-Off	5	NR	NR	NR		
Diluted for (Bath) Use	NR	NR	NR	NR		
<b><i>Exposure Type</i></b>						
Eye Area	NR	NR	NR	NR		
Incidental Ingestion	NR	NR	NR	NR		
Incidental Inhalation-Spray	NR	NR	NR	NR		
Incidental Inhalation-Powder	NR	NR	NR	NR		
Dermal Contact	3	NR	NR	NR		
Deodorant (underarm)	NR	NR	NR	NR		
Hair - Non-Coloring	2	NR	1	NR		
Hair-Coloring	NR	NR	NR	NR		
Nail	NR	NR	NR	NR		
Mucous Membrane	1	NR	NR	NR		
Baby Products	NR	NR	NR	NR		

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