Scientific Committee on Consumer Safety

SCCS

OPINION ON

2,6-Diaminopyridine

COLIPA n° A136

The SCCS adopted this opinion at its 14th plenary meeting

of 27 March 2012

About the Scientific Committees

Three independent non-food Scientific Committees provide the Commission with the scientific advice it needs when preparing policy and proposals relating to consumer safety, public health and the environment. The Committees also draw the Commission's attention to the new or emerging problems which may pose an actual or potential threat.
They are: the Scientific Committee on Consumer Safety (SCCS), the Scientific Committee on Health and Environmental Risks (SCHER) and the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and are made up of external experts.

In addition, the Commission relies upon the work of the European Food Safety Authority (EFSA), the European Medicines Agency (EMA), the European Centre for Disease prevention and Control (ECDC) and the European Chemicals Agency (ECHA).

SCCS

The Committee shall provide opinions on questions concerning all types of health and safety risks (notably chemical, biological, mechanical and other physical risks) of non-food consumer products (for example: cosmetic products and their ingredients, toys, textiles, clothing, personal care and household products such as detergents, etc.) and services (for example: tattooing, artificial sun tanning, etc.).

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This opinion has been subject to a commenting period of four weeks after its initial publication. Comments received during this time have been considered by the SCCS and discussed in the subsequent plenary meeting. Where appropriate, the text of the relevant sections of the opinion has been modified or explanations have been added. In the cases where the SCCS after consideration and discussion of the comments, has decided to maintain its initial views, the opinion (or the section concerned) has remained unchanged. Revised opinions carry the date of revision.

TABLE OF CONTENTS

1. BACKGROUND

Submission I for 2,6-Diaminopyridine was submitted December 2006 by a Japanese company through COLIPA.

2. TERMS OF REFERENCE

1. *Does SCCS consider 2,6-Diaminopyridine safe for consumers when used as an ingredient in oxidative hair dye products with a maximum concentration of 0.15% on the scalp, taken into account the scientific data provided?*

2. *Does the SCCS recommend any further restrictions with regard to the use of 2,6-Diaminopyridine in oxidative hair dye formulations?*

3. OPINION

3.1. Chemical and Physical Specifications

3.1.1. Chemical identity

3.1.1.1. Primary name and/or INCI name

2,6-Diaminopyridine (INCI name)

3.1.1.2. Chemical names

2,6-diaminopyridine
Pyridine-2,6-diamine

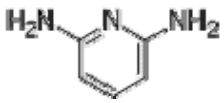
3.1.1.3. Trade names and abbreviations

2,6-Diaminopyridine

3.1.1.4. CAS / EC number

CAS: 141-86-6
EC: 205-507-2

3.1.1.5. Structural formula



3.1.1.6. Empirical formula

Formula: $C_5H_7N_3$

3.1.2. Physical form

Slightly Brown powder

3.1.3. Molecular weight

Molecular weight: 109.13 g/mol

3.1.4. Purity, composition and substance codes

Lot A3221
Content: 99.7% was assayed by potentiometric titration using perchloric acid, single experiment
Loss on drying: 0.0% (single experiment); *0.01% reported in 90 day oral toxicity study*

Lot No. A1426, A3221, A9554

According to the study report Identification and assay of 2,6-diaminopyrimidine was performed according to methods described in Japanese Pharmacopoeia. The methods used were:

UV, 200-400 nm, Thin-layer Chromatography and nitrogen content (Kjeldahl method),

Purity assayed by
Nitrogen content A1426=96.42%, A3221=97.76%, A9554= 97.5%

Purity assayed by
Gas Chromatography (Relative purity was determined as Area% without response factor: 100% - content of 2-aminopyridine – content of 4-aminopyridine): A1426=99.98%, A3221=99.86%, A9554= 99.99%
Loss on drying 0.0%
Loss on ignition 0- 0.04

Impurities (on 3 batches)

2-aminopyridine:	< 20 ppm (determined by GC-MS, using reference standard)
4-aminopyridine:	< 40 ppm (determined by GC-MS, using reference standard)
Unknown (7-16 GC peaks):	< 1500 (determined by GC, and calculated as concentration relative to 2,6-diaminopyridine)

Heavy Metals
Fe: < 20 ppm
Pb: < 20 ppm
As: < 2 ppm

Comment
The identification and quantification of 2,6-diaminopyridine were not performed using the state of the art methods such as IR, NMR, MS etc. Data on physico-chemical properties and IR and NMR spectra extracted from ACS on STN Registry No. 141-86-6 (2,6-diaminopyridine) were provided. However, no experiment was performed to demonstrate that IR and NMR of the test material were the same as reported in STN.
The contents determined by potentiometric titration and nitrogen content as well as relative purity determined mined by GC should be considered as semi-quantitative determination of 2,6-diaminopyridine in the above mentioned Lots.

3.1.5. Impurities / accompanying contaminants

See 3.1.4

3.1.6. Solubility

1g was dissolved in 10 ml water, 10 ml 95% ethanol and 1 ml DMSO

Comment
Water solubility has not been determined by EC Method A.6

3.1.7. Partition coefficient (Log P_{ow})

Log Po/w: Calculated solubility at 25°C and various pH is described

Comment
Log Po/w has not been determined by EC Method A.6

3.1.8. Additional physical and chemical specifications

Melting point:	122.1-122.6 °C
Boiling point:	285 °C
Flash point:	155 °C
Vapour pressure:	/
Density:	/
Viscosity:	/
pKa:	/
Refractive index:	/
pH:	/
UV_Vis spectrum (200-800 nm):	λmax 245±2 nm and 309±2 nm

3.1.9. Homogeneity and Stability

0.3 mg/ml and 3 mg/ml solutions of 2,6-diaminopyridine solutions in water were shown to be stable (variation <5%) when stored at room temperature for 8 days.

General Comments to physico-chemical characterisation

- The identification and quantification of 2,6-diaminopyridine were not performed using state of the art methods such as IR, NMR, MS etc. Data on physico-chemical properties and IR and NMR spectra extracted from ACS on STN Registry No. 141-86-6 (2,6-diaminopyridine) were provided. However, no experiment was performed to demonstrate that IR and NMR of the test material were the same as reported in STN.
- The contents determined by potentiometric titration and nitrogen content as well as relative purity determined mined by GC should be considered as semi-quantitative determination of 2,6-diaminopyridine in the above mentioned Lots.
- Water solubility has not been determined by EC Method A.6.
- Log Po/w has not been determined by EC Method A.6.
- Stability of 2,6-diaminopyridine has not been demonstrated in typical hair dye formulations.

3.2. Function and uses

2,6-diaminopyridine is used in oxidative hair colouring products at a maximum concentration of 0.3%, which after mixing in a 1:1 ratio with hydrogen peroxide just prior to use, corresponds to a concentration of 0.15% upon application.

3.3. Toxicological Evaluation

3.3.1. Acute toxicity

3.3.1.1. Acute oral toxicity

Guideline:	OECD 423 (2001)
Species/strain:	rat, Sprague-Dawley [Crl:CD (SD), SPF]
Group size:	9 female rats (3 animals per step)
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	distilled water
Dose levels:	50 (step 2 and 3) and 300 mg/kg bw (step 1)
Administration:	oral (gavage)
GLP:	in compliance
Study period:	14 March – 13 April 2006

A single dose acute oral toxicity test was performed in female rats using the acute toxic class method. The test substance dissolved in water was administered at 300 mg/kg bw to 3 animals (step 1). At step 2 and 3, 50 mg/kg bw was given. Animals were observed for 15 days. Body weight of animals was determined just before the administration and on days 2, 4, 8, 11 and 15 during the observation period. All study animals were autopsied after death.

Results
The animals administered with 300 mg/kg of the test item showed extreme salivation, tremor, clonic and tonic convulsions, and died within approximately 1 hour. Following the dose of 50 mg/kg bw salivation, paleness of skin and ptosis were observed. These changes were absent 4 hours after the administration; thereafter, any abnormalities were not observed from the next day of administration to the day of autopsy. Body weight gain of 4/6 animals of the 50 mg/kg bw group was normal.

Conclusion
The LD_{50} was between 50-300 mg/kg bw.

Ref.: 2

3.3.1.2. Acute dermal toxicity

No data submitted

3.3.1.3. Acute inhalation toxicity

No data submitted

3.3.2 Irritation and corrosivity

3.3.2.1. Skin irritation

Guideline:	OECD 404 (2002)
Species/strain:	rabbit, Kbl:NZW (SPF)
Group size:	4 females
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%

Vehicle:	distilled water
Dose level:	3% (w/v) test substance in water
Dose volume:	0.5 mL
Observation:	1, 24, 48, and 72 hours after the removal of patches
GLP:	in compliance
Study period:	4 – 7 April 2006

A skin irritation study using rabbits was performed to investigate the irritative and corrosive potential of a 3% 2,6-diaminopyridine in water solution. A 0.5 mL volume of 3% test substance in water solution was applied to a lint patch and this patch was affixed to the dorsal skin of 3 New Zealand white female rabbits for 4 hours. Skin responses and general condition of animals were observed at 1, 24, 48, and 72 hours after the removal of patches. Animal body weights were measured just before the application and 72 hours after the removal of patches (at the end of the observation period).

Results
No abnormality was observed in any of the 3 application sites at 1, 24, 48, and 72 hours after removal of patches. Therefore, a 3% 2,6-diaminopyridine in water solution was judged to be a non irritant.

Conclusion
From the above results, a 3% 2,6-diaminopyridine in water solution was judged to be a non irritant to the skin of the rabbits under the conditions in this study.

Ref.: 3

3.3.2.2. Mucous membrane irritation

Guideline:	OECD 405 (2002)
Species/strain:	rabbit, Kbl:NZW (SPF)
Group size:	6 females (irrigation group: 3 animals; non-irrigation group: 3 animals)
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	distilled water
Dose level:	3% (w/v) test substance in water
Dose volume:	0.1 mL
Observation:	1, 24, 48, and 72 hours after application
GLP:	in compliance
Study period:	4 – 7 April 2006

An eye irritation study using rabbits was performed to investigate the irritation and corrosive potential of a 3% 2,6-diaminopyridine in water solution. A 0.1 mL volume of 3% test substance in water solution was applied to eyes of 6 female New Zealand white rabbits. Three rabbits for a non irrigation group and irrigation group were used to investigate an irrigation effect. Eye responses and general condition of animals were observed at 1, 24, 48, and 72 hours after application.

Results
In non irrigation group, slight redness of conjunctivae was observed in only one eye at 1 hour after application. No abnormality was observed in the other 2 eyes in this group during the observation period. There was no obvious difference between non irrigation group and irrigation group, because no irritable responses were observed at any eye in irrigation group.

Conclusion
From the above results, a 3% 2,6-diaminopyridine in water solution was judged by the study authors to be a non irritant or mild irritant to the eye of the rabbits under the

conditions in this study. The study was unable to confirm an irrigation effect from the results due to a very mild irritation of a 3% 2,6-diaminopyridine in water solution.

Ref.: 4

Comment of the SCCS
A 3% 2,6-diaminopyridine solution in water was slightly irritant.

3.3.3. Skin sensitisation

Local Lymph Node Assay (LLNA)

Guideline:	OECD 429 (2002)
Species/strain:	mouse, CBA/JNCrlj [SPF]
Group size:	20 females (4 animals per dose group)
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	acetone: olive oil (4:1)
Concentration:	0, 0.25, 0.50 and 1.0% w/v
Positive control:	α-hexylcinnamaldehyde, 25% v/v
GLP:	in compliance
Study period:	5 – 11 April 2006

The mouse local lymph node assay (LLNA) was conducted to evaluate the skin sensitizing potential of 2,6-diaminopyridine by using 22 female CBA/JNCrlj [SPF] mice. This study consisted of 5 groups, including 3 doses of 2,6-diaminopyridine, no-treatment, and 25% v/v α-hexylcinnamaldehyde as positive control. Each group consisted of 4 mice.

Results
The SI (stimulation index) values for 0.25% w/v, 0.5% w/v, and 1% w/v 2,6-diaminopyridine groups were 3.4, 3.4, and 5.3, respectively. The SI value of the positive control group was 18.6.

Conclusion
On the basis of these results, it was concluded that 2,6-diaminopyridine was a strong sensitizer under the conditions in the present study, and the concentration of the test substance which induced an SI value of 3 was estimated to be 0.25% w/v.

Ref.: 5

Comment
An EC3 value of 0.09% was derived from the data. 2,6-diaminopyridine is an extreme sensitiser.

3.3.4. Dermal / percutaneous absorption

Guideline:	OECD 428 (2004)
Species/strain:	pig ear skin (6 females)
Membrane integrity:	tritiated water
Group size:	6 chambers
Method:	Franz-type horizontal static cells (1.77 cm²)
Test substance:	2,6-diaminopyridine [^{14}C]-2,6-diaminopyridine
Batch:	A3221 3551167 (radiolabelled)
Purity:	99.7% 98.8% (HPLC) (radiolabelled)
Test item:	hair dye formulation containing 0.147% 2,6-diaminopyridine

Dose volume: 100 µL (84.7 µg/cm² 2,6-diaminopyridine)
Receptor fluid: phosphate buffered saline
Method of Analysis: liquid scintillation counter
GLP: in compliance
Study period: 8 – 24 February 2006

To clarify in vitro percutaneous penetration of 2,6-diaminopyridine, the radioactivity of receptor fluid and the mass balance were investigated using pig skin with Franz-type cells after the application of a typical oxidative hair dye formulation containing ^{14}C-2, 6-diaminopyridine.

Results
The skin was wiped off using cotton after 30 minutes of exposure, and the radioactivity of the cotton was 97.70% of applied dose. The radioactivity of the receptor fluid, donor chamber washing, terminal skin rinse (at 24 hours), filter paper (the moisture of the skin), corneum (tape strips), epidermal and dermal membranes, and flange skin was 0.24%, 0.14%, 0.06%, 0.01%, 0.68%, 0.74% and 0.01%, respectively, resulting in 99.57% of total recovery.
The percentage of applied dose in receptor fluid at 2, 4, 6, 8 and 24 hours after application of the hair dye formulation containing 14C-2,6-diaminopyridine was 0.02%, 0.08%, 0.12%, 0.15% and 0.24%, respectively. The permeability of 14C-2,6-diaminopyridine at 2, 4, 6, 8 and 24 hours after application was 0.01, 0.07, 0.10, 0.12 and 0.20 µg eq./cm², respectively.

Table 1: Percentage of applied dose in receptor fluid and skin after application of hair dye formulation containing 0.147% 2,6-diaminopyridine at 100 µL/1.77 cm² to pig skin for 30 minutes

Sample	% of applied dose (Permeability, µg eq./cm^2)
Receptor fluid	0.24 ± 0.05
	(0.20 ± 0.04)
Donor chamber	0.14 ± 0.07
Cotton	97.70 ± 1.11
Rince	0.06 ± 0.04
Filter paper	0.01 ± 0.01
Corneum	0.68 ± 0.22
Epidermis and dermis	0.74 ± 0.18
	(0.62 ± 0.15)
Flange	0.01 ± 0.00
Total recovery	99.57 ± 1.08
Absorption ratio	0.98 ± 0.23
	(0.82 ± 0.18)

Each value represents the mean±S.D. of six pig skins.
Absorption ratio was calculated by the sum of percentage receptor fluid, epidermis and dermis.

Table 2: Individual percentage of applied dose in receptor fluid and skin after application of hair dye formulation containing 0.147% 2,6-diaminopyridine at 100 µL/1.77 cm² to pig skin for 30 minutes

		% of applied dose (Permeability, µg eq./cm²)					
Sample	Animal No.	1	6	7	8	9	10
Receptor fluid		0.19 (0.16)	0.32 (0.26)	0.29 (0.24)	0.25 (0.20)	0.21 (0.18)	0.19 (0.16)
Donor chamber		0.15	0.02	0.11	0.24	0.18	0.11
Cotton		97.21	96.91	99.14	96.63	99.06	97.25
Rince		0.12	0.02	0.02	0.05	0.06	0.09
Filter paper		0.01	0.01	0.01	0.00	0.01	0.00
Corneum		0.64	0.39	0.68	0.62	0.64	1.08
Epidermis and dermis		0.84 (0.70)	0.94 (0.78)	0.80 (0.66)	0.82 (0.69)	0.62 (0.52)	0.43 (0.36)
Flange		0.01	0.01	0.02	0.01	0.01	0.01
Total recovery		99.17	98.62	101.07	98.62	100.79	99.16
Absorption ratio		1.03 (0.86)	1.26 (1.04)	1.09 (0.90)	1.07 (0.89)	0.83 (0.70)	0.62 (0.52)

Absorption ratio was calculated by the sum of percentage receptor fluid, epidermis and dermis.

After application of the hair dye formulation, the absorption ratio of 2, 6-iaminopyridine was calculated to be 0.98% by a sum of receptor fluid (0.24%) and epidermis and dermis (0.74%), corresponding to 0.82 ± 0.18 µg eq./cm².

Ref.: 14

Comment
The authors justified the use of 56.5 µl/cm² instead of 10 µL/cm² based on the hair dye had to be washed out completely at 30 or 40 min after application.
The thickness of the membrane is not reported. Only 6 chambers were used.
Mean + 2 SD may be used to calculate MoS (1.18 µg/cm²).

3.3.5. Repeated dose toxicity

3.3.5.1. Repeated Dose (28 days) oral / dermal / inhalation toxicity

No data submitted

3.3.5.2. Sub-chronic (90 days) oral / dermal / inhalation toxicity

Guideline:	OECD 408 (1998)
Species/strain:	rat, Sprague-Dawley [Crl:CD (SD), SPF]
Group size:	50 males and 50 females Toxicity study: 10 males and 10 females per dose group Recovery study (0, 30 mg/kg bw/d): 5 males and 5 females per dose group
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	distilled water
Dose levels:	0, 3, 10 and 30 mg/kg bw/d

Dose volume: 1 mL per 100 g bw
Route: oral, gavage
Administration: once daily for 92 consecutive days, 29 days recovery period
GLP: in compliance
Study period: 13 September 2005 – 31 March 2006

A 90-day repeated oral dose toxicity study of 2,6-diaminopyridine in Crl:CD(SD) rats was conducted. Ten male and 10 female rats were assigned to each of four groups, a total of 80 rats were used in the study. 2,6-Diaminopyridine at doses of 0, 3, 10, and 30 mg/kg bw (water for injection was used as the vehicle) was orally administered to rats for each dose daily for 92 consecutive days. Animals were observed for general condition, body weight and food consumption were measured, and the functional observational battery (FOB) was conducted. In addition, urinalysis and ophthalmological examinations were conducted at week 13 of dosing. Examination of haematology, blood coagulation, blood chemistry, organ weights, and pathology were conducted at the end of the administration period. Five males and 5 females each in the satellite groups (control and 30 mg/kg bw/d groups) were observed for 29 days after cessation of the dosing of the test substance and were examined for recovery from toxic changes.

Results
No animals died during the administration or recovery period. As clinical signs, lacrimation, salivation, and ptosis of the eyelids were observed in both males and females given 10 mg/kg or more. The body weights in males in the 30 mg/kg bw/d group decreased during the administration period. The food consumption in both males and females in the 30 mg/kg bw/d group decreased in the early administration period. In the detailed observation on the functional observational battery (FOB), the number of animals showing salivation increased in both males and females in the 10 and 30 mg/kg bw/d groups. Decreased spontaneous motor activity was observed in males in the 10 and 30 mg/kg bw/d groups. The number of females sitting in the open field in the 30 mg/kg bw/d group increased. The number of rearing behaviour in females in the 30 mg/kg bw/d group decreased.
The haematocrit concentrations, haemoglobin concentrations, and red blood cell counts in males or females, or both in the 30 mg/kg bw/d group decreased, the MCV, MCH, and reticulocyte ratios in these animals increased. These findings suggested anaemia. In addition, the lymphocyte counts in males in the 30 mg/kg bw/d group increased. High reticulocyte counts in males in the 3 mg/kg bw/d group were noted but not judged to be test substance related because there were no changes in any of the other haematological parameters and no dose-response relationship. No toxic changes caused by the test substance were observed in the examinations of blood coagulation and clinical biochemistry.
In urinalysis, the urine volumes in males in the 10 and 30 mg/kg bw/d groups increased, and the osmotic pressures in these animals decreased. The number of males having leukocytes in the urine sediments in the 10 and 30 mg/kg bw/d groups and the number of males having renal tubular epitheliocytes in the urine sediments in the 30 mg/kg bw/d group increased. The urine volumes in females in the 10 and 30 mg/kg bw/d groups increased, and the osmotic pressures in these animals decreased. The number of females showing a positive reaction for urinary glucose and/or urinary protein in the 30 mg/kg bw/d group increased and the number of females showing a positive reaction for bilirubin in the 10 and 30 mg/kg bw/d groups increased. Furthermore, the number of females having renal tubular epitheliocytes in the urine sediments in the 10 and 30 mg/kg bw/d groups increased. In ophthalmology, no effects related to the administration of the test substance were observed. The kidney weights in both males and females in the 10 and 30 mg/kg bw/d groups increased, the liver weights in females in the 10 and 30 mg/kg bw/d groups increased, and the spleen weights in females in the 30 mg/kg bw/d group also increased.

In pathology, single cell necrosis of renal tubular epithelium and regeneration of epithelium in the proximal tubule (P3 segment) was observed in many male and female animals in the 10 and 30 mg/kg bw/d groups, and it was moderate in grade in 1 male in the 30 mg/kg bw/d group and in some females in the 10 and 30 mg/kg bw/d groups, more severe in

females. Moderate or severe hyaline droplet in the proximal tubule was observed in males in the 10 and 30 mg/kg bw/d groups. In addition, brown pigment deposition in the proximal tubule was observed in females in the 30 mg/kg bw/d group. As treatment-related gross findings in the spleen, dark-coloration was observed in females in the 30 mg/kg bw/d group. Histopathologically, increased pigment deposition and increased extramedullary haematopoiesis were observed in both males and females in the 10 and 30 mg/kg bw/d groups; it was moderate in grade in females in the 30 mg/kg bw/d group. With these lesions of the spleen, congestion was observed in males in the 30 mg/kg bw/d group and females in the 10 and 30 mg/kg bw/d groups. A type of anaemia observed in the 30 mg/kg bw/d group was judged to be haemolytic anaemia. As histopathological hepatic findings, eosinophilic change of hepatocyte was observed in males in the 10 and 30 mg/kg bw/d groups and females in the 30 mg/kg bw/d group. Centrilobular hepatocellular hypertrophy was observed in 1 female in the 30 mg/kg bw/d group. In the recovery study, dark spleen was grossly observed in 3 females in the 30 mg/kg group, and increased pigment deposition was histopathologically observed in 4 females in the 30 mg/kg bw/d group. The treatment-related histopathological findings observed in the kidney, liver, and spleen in the toxicity study disappeared or the degree of pigment deposition of the spleen decreased in the recovery study. Therefore, treatment-related histopathological findings in the toxicity study were considered to be reversible changes. The kidney, erythrocyte, and liver were target organs for the test substance.

Conclusion
The results from this study clearly demonstrated the 90-day repeated oral dose toxic effects of 2,6-diaminopyridine at 10 and 30 mg/kg bw/d on the Crl:CD(SD) rats. From these results, the no observed adverse effect level was judged to be 3 mg/kg bw/d in both males and females. The animals recovered from most toxic changes after the 4-week substance withdrawal. The erythrocytes, kidney, spleen, and liver were target organs for 2,6-diaminopyridine induced toxicity.

Ref.: 6

3.3.5.3. Chronic (> 12 months) toxicity

No data submitted

3.3.6. Mutagenicity / Genotoxicity

3.3.6.1 Mutagenicity / Genotoxicity *in vitro*

Bacterial Reverse Mutation Assay

Guideline:	OECD 471 (1997)
Species/Strain:	*Salmonella typhimurium* TA100, TA1535, TA98, TA1537; *E. coli* WP2 uvrA
Replicates:	Triplicate plates in two independent studies.
Treatment:	preincubation method
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	Distilled water
Concentration:	0, 313, 625, 1250, 2500, 5000 µg/plate without and with S9-mix
Positive control:	without S9-mix: AF-2 (2-(2-furyl)-3-(5-nitro-2-furyl)acrylamide) SA (sodium azide) 9AA (9-aminoacridine) With S9-mix 2AA 2-aminoanthracene)

GLP: in compliance
Study period: 27 February – 16 March 2006

2,6-diaminopyridine was investigated for the induction of gene mutations in bacteria with and without phenobarbital/5,6-benzoflavon induced rat liver S9-mix. A preliminary toxicity study with 8 concentrations from 1.5 to 5000 µg/plate was performed. The concentrations in the main tests were based on the results from the initial toxicity study, where no growth inhibition was observed.

Results
No toxicity, measured as growth inhibition of tester strains, was observed in any strains used with or without S9-mix. No precipitation derived from the test item was observed at any concentration tested with or without S9-mix.
The number of revertants did not increase more than twice that of the negative control in any strains used with or without S9-mix in the duplicate mutagenicity tests.

Conclusion
Based on the results in this study and under the experimental conditions performed it is concluded the 2,6-diaminopyridine did not induce gene mutations in bacteria.

Ref.: 7

In vitro Mammalian Cell Gene Mutation Test

Guideline:	OECD 476 (1997)	
Species/strain:	mouse lymphoma cell line (L5178Y $tk^{+/-}$)	
Replicates:	One single culture in two independent experiments	
Test substance:	2,6-diaminopyridine	
Batch:	A3221	
Purity:	99.7%	
Vehicle:	Sterile water	
Treatment:	Experiment I:	3 h treatment without and with S9-mix; expression period 48 h and selection period of 12-14 days
	Experiment II:	24 h treatment without S9-mix; expression period 48 h and selection period of 12-14 days
Concentrations:	short term without S9-mix 18.3, 30.5, 50.9, 84.8, 141, 236, 393, 655, 1091 µg/mL short term with S9-mix 0.855, 1.42, 2.37, 3.96, 6.60, 11.0, 18.3, 30.5, 50.9, 84.8 µg/mL continuous treatment, 24h 6.60, 11.0, 18.3, 30.5, 50.9, 84.8, 141, 236, 393, 655 µg/mL	
Positive control:	Methyl methanesulfonate (MMS):	without S9-mix
	Cyclophosphamide	with S9-mix
GLP:	in compliance	
Study period:	20 February – 28 March 2006	

A136 was tested for the induction of gene mutations at the *tk* locus of mouse lymphoma cells both in the absence and presence phenobarbital/5,6-benzoflavon induced rat liver S9-mix. Test concentrations were based on the results of a pre-test on toxicity with exposure up to the prescribed maximum concentration of 10 mM (≈ 1091 µg/ml) measuring relative suspension growth. Toxicity was measured in the main experiments as percentage relative total growth (RTG) of the treated cultures relative to the total growth of the solvent control cultures. To discriminate between large (indicative for mutagenic effects) and small colonies (indicative for a clastogenic effect) colony sizing was performed. Negative and positive controls were in accordance with the OECD guideline.

Results

No precipitation of the test substance was observed at any concentrations or treatments.
In the first experiment without S9-mix toxicity was not below 10% at any tested concentrations, and (all) 9 concentrations were evaluated. In the other experiments severe toxicity (RTG below 10%) was observed at the highest tested concentration(s) and 8 (with S9-mix and 3 h exposure) or 9 (24 h without S9-mix) concentrations were evaluated. In all experiments a clear and concentration related increase in mutant frequency was observed. There was no significant increase in small colonies in any of the experiments, indicating a mutagenic but not a clastogenic effect of the test substance.

Conclusion
Under the experimental conditions performed A136 induced gene mutations in mammalian cells in this *in vitro* assay.

Ref.: 8

***In vitro* Mammalian Chromosome Aberration Test**

Guideline:	OECD 473 (1997)
Species/strain:	cultured Chinese Hamster Lung cells (CHL/IU)
Replicates:	Two cultures in two independent tests
Test item:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	water
Concentrations:	short term (6 h) without S9-mix 0.28, 0.55, 1.1 mg/mL short term (6 h) with S9-mix 0.14, 0.28, 1.1 mg/mL continuous treatment, 24h 0.069, 0.14, 0.28 mg/mL
Performance:	6 h or 24 h treatment without S9-mix; harvest time 24 h after the start of treatment 6 h treatment with S9-mix; harvest time 24 h after start of treatment
Positive controls:	mitomycin C cyclophoshamide
GLP:	in compliance
Study period:	24 February – 19 April 2006

A136 was tested for the induction of chromosomal aberrations in Chinese hamster female lung cells both with and without phenobarbital/5,6-benzoflavon induced rat liver S9-mix.
A preliminary toxicity test was performed in order to determine the concentration range for the cytogenetic test. Based on the results from this pre-test the highest concentration selected for evaluation was 1.1 mg/mL (≈ 10 mM).

Results
No precipitation was observed at any concentration tested. No toxicity was observed after short term treatment without S9-mix. After short term treatment with S9-mix and continuous treatment for 24 h a dose dependant decrease in cell growth was observed. However, an unexpected but reproducible increase in cell growth was observed at the highest concentration with S9-mix, resulting in a U-shaped concentration-response curve. This was the reason for the concentration selection with S9-mix (omitting the most toxic concentration of 0.55 µg/mL). Although, there was a statistical significant increase in structural chromosomal aberrations after short term treatment with S9-mix at all evaluated concentrations (percentage of cells with aberrations excluding gaps: 24%, 51% and 9% at 0.14, 0.28 and 1.1 mg/mL respectively, compared to 1% in the negative control and 44% in the positive control), the trend test was negative. No statistical significant increase in cells

with chromosomal aberrations was observed without S9-mix after short term treatment. After continuous treatment without S9-mix a statistically significant increase in structural chromosomal aberrations was observed at the highest tested concentration. No increase in numerical aberrations was observed.

Conclusion
Under the experimental conditions performed A136 was clastogenic in mammalian cells.
Ref.: 9

3.3.6.2 Mutagenicity/Genotoxicity *in vivo*

***In vivo* Mammalian Erythrocytes Micronucleus Test**

Guideline:	OECD 474 (1997)
Species/strain:	ICR mice [Crj:CD-1 (ICR), SPF]
Group size:	5 male mice per dose group
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	0.5% methylcellulose solution
Dose level:	0, 7.5, 15, 30 mg/kg bw/d 50 mg/kg bw/d (cyclophosphamide)
Route:	oral
Administration:	2 dosings at an interval of 24h Positive control: 1 dosing
Positive control:	cyclophosphamide monohydrate
GLP:	in compliance
Study period:	2 June – 30 July 2004

The clastogenic/aneugenic activity of A136 was measured in the micronucleus assay in mice after oral administration. Preliminary toxicity tests were carried out to obtain the maximum tolerated dose (MTD), and a main micronucleus test was carried out based on the results of preliminary toxicity tests.

The first preliminary toxicity test was planned to administer orally to male and female mice twice at 24-hour intervals, at doses of 250, 500, 1000 and 2000 mg/kg bw/day of 2,6-diaminopyridine. However, the second dosing was not carried out, since all the mice in the groups of 500 mg/kg bw/day and more died shortly after the first dosing, and mice in the group of 250 mg/kg bw/day (males and females) died within 24 hours after the first dosing. Since the MTD was not obtained from the first preliminary toxicity test, the second preliminary toxicity test was carried out at five doses of 7.81, 15.6, 31.3, 62.5 and 125 mg/kg bw/day. As no difference was observed in the time of death between males and females in the first preliminary toxicity test, it was judged that there was no marked difference in toxicity between the two sexes. Therefore, only male mice were used in the second preliminary toxicity test. As a result, death was observed in the groups of 62.5 mg/kg bw/day and more; therefore, the MTD was set at 31.3 mg/kg bw/day.
Based on preliminary toxicity tests, the main micronucleus test was carried out using male mice by 2 oral administrations at 24-hour intervals, of 24 hours with dose levels of 7.5, 15 and 30 mg/kg bw/day of 2,6-diaminopyridine. Smear specimens of bone marrow cells were prepared 24 hours after the last dosing, and microscopic observation was carried out.

Results
In the main test toxicity was observed as a decrease in locomotor activity at the highest dose tested. No other sign of toxicity was observed at any tested doses, although the substance was tested up to MTD.

2,6-diaminopyridine did not induce a statistical significant or biological relevant increase of micronucleated polychromatic erythrocytes (MNPCEs). The proportion of polychromatic erythrocytes in erythrocytes in any 2,6-diaminopyridine dosed group or the positive control group was not significantly different from that in the negative control group. Thus, suppression of bone marrow cell proliferation by administration of the test item was not observed. However, there was some toxicity at the highest tested dose, indicating systemic availability. In addition in the 90 days study in rats, there was a decrease in red blood cell counts at 30 mg/kg bw/day. This effect may also indicate that the substance was systemically available. The frequency of MNPCEs was significantly increased at a level of 1% in the positive control group (cyclophosphamide monohydrate 50 mg/kg bw).

Conclusion
It was concluded that 2,6-diaminopyridine has neither a clastogenic nor an aneugenic potential in bone marrow cells of mice under these experimental conditions.

Ref.: 10

Unscheduled DNA Synthesis (UDS) Test with Mammalian Liver Cells *In Vivo*

Guideline:	OECD 486 (1997)
Species/strain:	rat, Crj: CD (SD) IGS [SPF]
Group size:	Four male rats for each of the 8 test groups
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	water for injection
Dose level:	0, 120, 240 mg/kg bw
Dosing volume:	1 mL per 100 g bw
Route:	oral
Administration:	2 dosings at an interval of 24h
Control:	dimethylnitrosamine (DMN), 5 mg/kg bw, 2-hour treatment group 2-acetylaminofluorene (2AAF), 100 mg/kg bw, 16-hour treatment group
Treatment:	2 and 16h treatment
GLP:	in compliance
Study period:	10 December 2003 – 19 February 2004

An *in vivo/in vitro* unscheduled DNA synthesis assay with rat hepatocytes was conducted to examine the DNA damaging potential of 2,6-diaminopyridine.
As a result of a dose-finding study, 2 deaths in the highest dose group of 480 mg/kg bw were observed until 16 hours after administration. No death was observed in the dose groups of 240 mg/kg bw or less. Therefore, in this assay a single oral dose was used to compare a 240 mg/kg dose, which was considered to be near to the maximum tolerated dose (MTD), with a 120 mg/kg bw dose (as a low dose) in this.
Hepatocytes were isolated by the collagenase perfusion method at 2 or 16 hours after administration, and cultured. Thereafter, the nuclear grain count and cytoplasm grain count were determined.

Results
The mean net nuclear grain (NNG) counts of the 2,6-diaminopyridine treatment groups were comparable to those of the negative control group. The incidence of cells in repair (UDS positive) in the treatment groups was also comparable to that of the negative control group, showing no remarkable trend of increase.
In two positive control groups, i.e., in a group treated with dimethylnitrosamine (DMN: 5 mg/kg dose) for 2 hours and in a group treated with 2-acetylaminofluorene (2AAF: 100 mg/kg dose) for 16 hours, the hepatocytes of all rats showed large counts of NNG and high DNA repair cell appearance frequencies, indicating a positive reaction.

Conclusion
It was concluded that 2,6-diaminopyridine did not have DNA damaging potential under the test conditions used.

Ref.: 11

3.3.7. Carcinogenicity

In vitro Syrian Hamster Cells (SHE) Transformation Assay

Guideline:	/
Species/strain:	Syrian Hamster Embryo (SHE) cells
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	DMSO
Concentrations:	200, 400, 500, 550, 575, 600, 625 µg/mL
Positive control:	benzo[a]pyrene, 5 µg/mL
GLP:	in compliance
Study period:	2 July 2004 – 5 March 2005

Cryopreserved cell stocks of both target and feder SHE cells were prepared from embryo cells derived from time-pregnant Syrian golden hamster at 13 to 13.5 days of gestation. The cells were kept in liquid nitrogen. The SHE cells were cultured in LeBoef's modification of Dulbecco's Modified Medium (DMEM) suplemented with 20% fetal bovine serum (FBS) and 4 mM L-glutamine. The sodium bicarbonate content of the medium was formulated to maintain a pH of 6.65 – 6.75. The cells were cultured at 37±1 °C in humidified air containing 10±0.5% CO_2. Sufficient target SHE cells expected to generate 25 – 45 colonies/dish were seeded in 2 ml of culture dishes containing 2 ml of culture medium and approximately $4x10^4$ feeder SHE cells (prevuously X-irradiated sufficiently to prevent replication) that were seeded 24 hours earlier. 45 dishes were prepared for each concentration of 2,6-diaminopyridine and control groups. The cultures were incubated for a period of 7 days.

While the positive control, benzo(a)pyrene, induced a significant number of morphologically altered colonies, none of the concentrations of 2,6-diaminopyridine caused a significant number of morphologically tranformed colonies.

It was concluded the 2,6-diaminopyridine did not induce transformation of SHE cells.

Ref.: 12

3.3.8. Reproductive toxicity

3.3.8.1. Two generation reproduction toxicity

No data submitted

3.3.8.2. Teratogenicity

Guideline:	OECD 414 (2001)
Species/strain:	rat, Sprague-Dawley [Crl:CD(SD), SPF]
Group size:	25 females per dose group
Test substance:	2,6-diaminopyridine
Batch:	A3221
Purity:	99.7%
Vehicle:	water for injection
Dose levels:	0, 3, 10, 30 mg/kg bw/d

Dose volume: 1 mL per 100 g bw
Route: oral (gavage)
Administration: daily during days 5 to 19 of gestation
GLP: in compliance
Study period: 26 December 2005 – 8 May 2006

A teratogenicity study with 2,6-diaminopyridine in rats was performed. 2,6-Diaminopyridine at doses of 3, 10, and 30 mg/kg bw (water for injection was used as the vehicle) was orally administered daily to 25 female successfully copulated Crl:CD(SD) rats for each dose during days 5 to 19 of gestation. During the gestation period, the general conditions of the dams were observed, and their body weights and food consumption were measured. Caesarean section and necropsy were performed on day 20 of gestation. The mortality, growth, and morphological abnormalities of the foetuses were recorded.

Results
None of the animals died or aborted during the gestation period. As clinical signs, lacrimation, salivation, and ptosis of the eyelids were observed in the 10 and 30 mg/kg bw/d groups. The test substance at 10 mg/kg bw/d caused a decrease in food consumption, and at 30 mg/kg bw/d decreases in body weight gain and food consumption. The gross post-mortem examinations revealed dark spleen in the 30 mg/kg bw/d group. There were no effects related to the administration of the test substance on the gravid uterus weights.

The mean female foetal weights and placental weights of live male and female foetuses in the 30 mg/kg bw/d group were significantly lower than those in the control group. There were no effects related to the administration of the test substance on the number of corpora lutea graviditatis, number of implantations, number of live foetuses, sex ratios, or number of resorption and dead foetuses. The placental examination and external and visceral examinations of the live foetuses did not reveal effects related to the administration of the test substance. The skeletal examinations did not reveal skeletal malformations or variations related to the administration of the test substance in any of the groups but revealed incomplete ossification of the thoracic vertebrae in the 30 mg/kg bw/d group. Slight retardation of foetal growth was suggested.

Conclusion
From these results, the no observed adverse effect level (NOAEL) for maternal toxicity was determined to be 3 mg/kg bw/d based on lacrimation, salivation, ptosis of the eyelids, and a decrease in food consumption at 10 mg/kg bw/d. The NOAEL for developmental toxicity in foetuses was determined to be 10 mg/kg bw/d due to foetal growth retardation at 30 mg/kg bw/d (decreases in foetal weights and placental weights, and incomplete ossification of the thoracic vertebrae). Teratogenicity was not observed even at 30 mg/kg bw/d.

Ref.: 13

3.3.9. Toxicokinetics

No data submitted

3.3.10. Photo-induced toxicity

3.3.10.1. Phototoxicity / photoirritation and photosensitisation

No data submitted

3.3.10.2. Phototoxicity / photomutagenicity / photoclastogenicity

No data submitted

3.3.11. Human data

No data submitted

3.3.12. Special investigations

No data submitted

3.3.13. Safety evaluation (including calculation of the MoS)

CALCULATION OF THE MARGIN OF SAFETY

Not applicable

3.3.14. Discussion

Physico-chemical properties
2,6-diaminopyridine is used in oxidative hair colouring products at a maximum concentration of 0.3%, which after mixing in a 1:1 ratio with hydrogen peroxide just prior to use, corresponds to a concentration of 0.15% upon application.
The identification and quantification of 2,6-diaminopyridine were not performed using the state of the art methods such as IR, NMR, MS etc. Data on physico-chemical properties and IR and NMR spectra extracted from ACS on STN Registry No. 141-86-6 (2,6-diaminopyridine) were provided. However, no experiment was performed to demonstrate that IR and NMR of the test material were the same as reported in STN.
The contents determined by potentiometric titration and nitrogen content as well as relative purity determined mined by GC should be considered as semi-quantitative determination of 2,6-diaminopyridine in the above mentioned Lots.
Water solubility has not been determined by EC Method A.6.
Log Po/w has not been determined by EC Method A.6.
Stability of 2,6-diaminopyridine has not been demonstrated in typical hair dye formulations.

General toxicity
In a single dose acute oral toxicity test in female rats using the acute toxic class method the LD_{50} of 2,6-diaminopyridine was between 50-300 mg/kg bw.
From the results of a 90-day repeated dose oral toxicity study in rats the no observed adverse effect level of 2,6-diaminopyridine was judged to be 3 mg/kg bw/d in both males and females. The erythrocytes, kidney, spleen, and liver were target organs of 2,6-diaminopyridine induced toxicity.

From the results of a developmental toxicity study in rats, the no observed adverse effect level (NOAEL) for maternal toxicity was determined to be 3 mg/kg bw/d based on lacrimation, salivation, ptosis of the eyelids, and a decrease in food consumption at 10 mg/kg bw/d. The NOAEL for developmental toxicity in foetuses was determined to be 10 mg/kg bw/d due to foetal growth retardation at 30 mg/kg bw/d (decreases in foetal weights and placental weights, and incomplete ossification of the thoracic vertebrae). Teratogenicity was not observed even at 30 mg/kg bw/d.

Irritation / sensitisation
A 3% 2,6-diaminopyridine in water solution was non irritant to the skin of the rabbits and slightly irritant to the eye of the rabbits under the conditions in the study.
2,6-diaminopyridine is an extreme sensitizer.

Dermal absorption
The dermal absorption of 2,6-diaminopyridine was investigated after application of a typical oxidative hair dye formulation.
The thickness of the membrane employed was not reported and only 6 chambers were used. The mean + 2 SD (1.18 µg/cm^2) may be used to calculate MoS.

Mutagenicity / genotoxicity
Overall 2,6 diaminopyridine was evaluated for the three endpoints of genotoxicity: gene mutations, structural chromosomal aberrations and aneuploidy. The test substance did not induce gene mutations in bacteria, but was mutagenic and clastogenic in mammalian cells. The genotoxic effects observed *in vitro* were not confirmed in two *in vivo* tests: a mouse micronucleus assay on bone marrow, and a rat UDS assay on liver cells.

Carcinogenicity
2,6-diaminopyridine did not induce transformation in the *in vitro* Syrian hamster transformation assay. No *in vivo* carcinogenicity studies have been submitted.

4. CONCLUSION

The SCCS is of the opinion that the information submitted is insufficient to allow a final risk assessment to be carried out.

Before any further consideration, the following information must be submitted:

- data on the characterisation and quantification of the test materials using state of the art methods.

5. MINORITY OPINION

Not applicable

6. REFERENCES

Submission I, 2006

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Data Base Literature Search

Literatures in relation to safety of 2,6-diaminopyridine were researched.

STN International (STN) is the online scientific and technical information service, and provides a complete collection of in-depth databases in science and technology.

STN was used with CAS registry number (automatically including all listed synonyms) to access information related to safety of 2,6-diaminopyridine in the following online databases:

RTECS, HSDB, MEDLINE, EMBASE, BIOSIS, ESBIOBASE, FSTA, LIFESCI, CSNB, HEALSAFE, ULIDAT, SCISEARCH, NTIS, TOXCENTER

In addition, TOXNET, one of the National Library of Medicine (NLM) databases and the National Toxicology Program (NTP) database were searched.

List of references not included in the safety assessment

The following studies were not included in the safety assessment due to missing information on the specification of the material (identity/quality), inadequate reporting and/or limitations in test performance (not GLP, not standard guideline).

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