



1
2
3
4
5
6
7
8
9
10

Scientific Committee on Consumer Safety

9
10

11
12
13
14
15
16

OPINION ON

18 Hydroxyanthraquinone-aminopropyl methyl morpholinium 19 methosulfate

20

COLIPA n° C117

22
23
24
25
26
27
28
29
30
31

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1

2 About the Scientific Committees

3 Three independent non-food Scientific Committees provide the Commission with the
4 scientific advice it needs when preparing policy and proposals relating to consumer safety,
5 public health and the environment. The Committees also draw the Commission's attention
6 to the new or emerging problems which may pose an actual or potential threat.

7 They are: the Scientific Committee on Consumer Safety (SCCS), the Scientific Committee
8 on Health and Environmental Risks (SCHER) and the Scientific Committee on Emerging and
9 Newly Identified Health Risks (SCENIHR) and are made up of external experts.

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

13 SCCS

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

19

20

21 Scientific Committee members

22 Ulrike Bernauer, Qasim Chaudhry, Gisela Degen, Elsa Nielsen, Thomas Platzek, Suresh
23 Chandra Rastogi, Christophe Rousselle, Jan van Benthem, Pieter Coenraads, Maria
24 Dusinska, David Gawkrodger, Werner Lilienblum, Andreas Luch, Manfred Metzler, Nancy
25 Monteiro-Rivière.

26

27

28 Contact

29 European Commission

30 Health & Consumers

31 Directorate C: Public Health

32 Unit C2 – Health Information/ Secretariat of the Scientific Committee

33 Office: HTC 03/073 L-2920 Luxembourg

34 SANCO-C2-SCCS@ec.europa.eu

35

36 © European Union, 2013

37 ISSN 1831-4767

ISBN 978-92-79-30112-4

38 Doi: 10.2772/67658

ND-AQ-13-005-EN-N

39

40 The opinions of the Scientific Committees present the views of the independent scientists
41 who are members of the committees. They do not necessarily reflect the views of the
42 European Commission. The opinions are published by the European Commission in their
43 original language only.

44

45 http://ec.europa.eu/health/scientific_committees/consumer_safety/index_en.htm

46

47

48

1

2 **ACKNOWLEDGMENTS**

3 **SCCS members**

4 Dr. E. Nielsen
5 Dr. W. Lilienblum
6 Prof. T. Platzek (chairman)
7 Dr. S.C. Rastogi (rapporteur)
8 Dr. Ch. Rousselle
9 Dr. J. van Benthem
10 Prof. D. Gawkrodger
11 Prof. M. Metzler

12

13 **External experts**

14 Prof. M.P. Vinardell
15 Dr. I.R. White
16 Prof. T. Sanner

17

18

19

20

21

22

23

24 Keywords: SCCS, scientific opinion, hair dye, hydroxyanthraquinone-aminopropyl methyl
25 morpholinium methosulfate, C117, directive 76/768/ECC, CAS 38866-20-5, EC 254-161-9

26

27

28

29 Opinion to be cited as: SCCS (Scientific Committee on Consumer Safety), Opinion on
30 hydroxyanthraquinone-aminopropyl methyl morpholinium methosulfate, 18 June 2013

31

32

TABLE OF CONTENTS

8	ACKNOWLEDGMENTS	3
9	1. BACKGROUND	5
10	2. TERMS OF REFERENCE.....	5
11	3. OPINION.....	6
12	3.1. Chemical and Physical Specifications.....	6
13	3.1.1. Chemical identity	6
14	3.1.2. Physical form	6
15	3.1.3. Molecular weight	6
16	3.1.4. Purity, composition and substance codes.....	7
17	3.1.5. Impurities / accompanying contaminants	7
18	3.1.6. Solubility	8
19	3.1.7. Partition coefficient (Log Pow)	8
20	3.1.8. Additional physical and chemical specifications.....	8
21	3.1.9. Homogeneity and Stability	8
22	3.2. Function and uses	9
23	3.3. Toxicological Evaluation	9
24	3.3.1. Acute toxicity	9
25	3.3.2. Irritation and corrosivity	10
26	3.3.3. Skin sensitisation.....	11
27	3.3.4. Dermal / percutaneous absorption.....	15
28	3.3.5. Repeated dose toxicity	16
29	3.3.6. Mutagenicity / Genotoxicity	17
30	3.3.7. Carcinogenicity.....	26
31	3.3.8. Reproductive toxicity	26
32	3.3.9. Toxicokinetics	27
33	3.3.10. Photo-induced toxicity	27
34	3.3.11. Human data.....	27
35	3.3.12. Special investigations	27
36	3.3.13. Safety evaluation (including calculation of the MoS).....	28
37	3.3.14. Discussion	28
38	4. CONCLUSION	29
39	5. MINORITY OPINION.....	29
40	6. REFERENCES	29

41
42
43

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1
2 **1. BACKGROUND**

3
4 Submission I on Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate
5 was submitted by COLIPA¹ in June 2003².

6
7 Submission II was submitted in July 2004 by COLIPA.

8
9 The Scientific Committee on Consumer Products (SCCP) adopted at its 3rd plenary meeting
10 on 15 March 2005 an opinion (SCCP/0875/03, final) with the conclusion that:

11
12 "The SCCP is of the opinion that the information submitted is inadequate to assess the safe
13 use of the substance. Before any further consideration, the following information is required
14 by July 2005:

- 15
16 * nature/characterisation of the impurities;
17 * nitrosamine content.

18
19 This hair dye, like many other hair dyes, is a skin sensitiser"

20
21 Submission III was submitted by COLIPA in July 2005. According to the former submission
22 the substance is used in direct hair dyes formulations at a maximum concentration of 0.5%.

23
24 Submission III presents updated scientific data on the above mentioned substance in line
25 with the second step of the strategy for the evaluation of hair dyes
26 (<http://europa.eu.int/comm/enterprise/cosmetics/doc/hairdyestrategyinternet.pdf>) within
27 the framework of the Cosmetics Directive 76/768/EEC.

28
29 **2. TERMS OF REFERENCE**

- 30
31 1. *Does the SCCS consider hydroxyanthraquinone aminopropyl methyl morpholinium
32 methylsulfate safe for use in non-oxidative hair dye formulations with a maximum
33 concentration of 0.5% taken into account the new scientific data provided?*
- 34
35 2. *Does the SCCS recommend any further restrictions with regard to the use of
36 hydroxyanthraquinone aminopropyl methyl morpholinium methylsulfate in any non-
37 oxidative hair dye formulations?*

¹ COLIPA - European Cosmetics Toiletry and Perfumery Association

² According to records of COLIPA

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1

2 **3. OPINION**3 **3.1. Chemical and Physical Specifications**4 **3.1.1. Chemical identity**6 **3.1.1.1. Primary name and/or INCI name**

8 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate (INCI name)

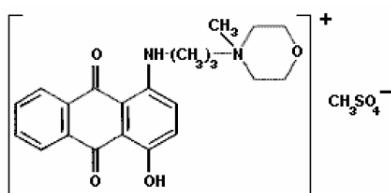
10 **3.1.1.2. Chemical names**12 1-N-Methylmorpholiniumpropylamino-4-hydroxyanthraquinone, methyl sulfate
13 4-[3-[(9,10-dihydro-4-hydroxy-9,10-dioxoanthryl)amino] propyl]-4-methylmorpholinium
14 methyl sulphate16 **3.1.1.3. Trade names and abbreviations**

18 Imexine BD (Chimex)

20 **3.1.1.4. CAS / EC number**

22 CAS: 38866-20-5

23 EC: 254-161-9

25 **3.1.1.5. Structural formula**29 **3.1.1.6. Empirical formula**31 Formula: C₂₂H₂₅N₂O₄ . CH₃SO₄33 **3.1.2. Physical form**

35 Violet powder

37 **3.1.3. Molecular weight**

39 Molecular weight: 492.5 g/mol

1 **3.1.4.Purity, composition and substance codes**

2 Batch OpT 54³ was used for all the analytical determinations reported.

5 Purity: 87.5% (by HPLC with ref. standard of pure substance - batch RF010)

6 Water: 2.2% (Karl Fisher method)

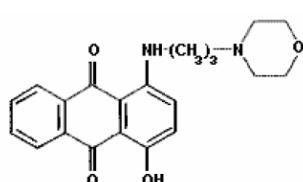
7 Ash: 0.12%

8 Methyl Sulphate ions: 22.5% w/w (theoretical value = 22.5% w/w)

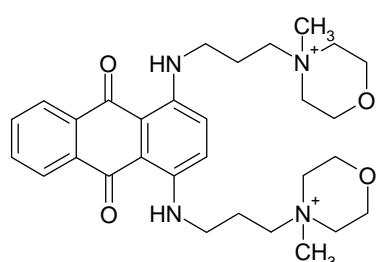
10 **3.1.5.Impurities / accompanying contaminants**

11 Identified Impurities:

14 1-Hydroxy-4-(3-morpholin-4-yl-propylamino)-anthracene-9,10-dione: 1.2%



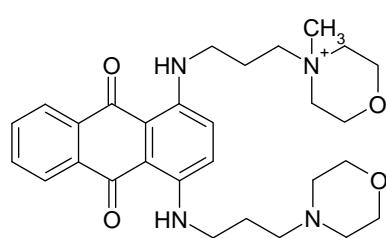
17 Three other impurities with following proposed chemical structures were identified
Impurity A, content 7% (mole/mole, semi-quantitative)



Exact Mass =522.3

Molecular Formula =[C₃₀H₄₂N₄O₄]²⁺

23 **Impurity B** content 2.6% (mole/mole, semiquantitative)

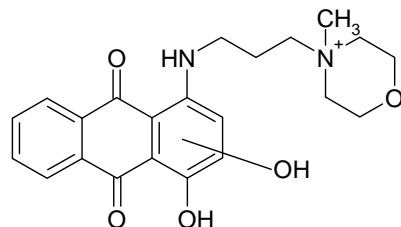


Exact Mass =507.3

Molecular Formula =[C₂₉H₃₉N₄O₄]⁺

27 **Impurity C**

³ various descriptions were found throughout whole report



Exact Mass =397.2

Molecular Formula =[C₂₂H₂₅N₂O₅]⁺

Residual solvents:

Acetone: Detected (Detection Limit < 100 ppm)

Ethanol: Not Detected (Detection Limit < 500 ppm)

Isobutanol: Not Detected (Detection Limit < 500 ppm)

Apparent Total Nitroso Content (ATNC) expressed as N-nitroso (NNO)

- Batch 0508813 : 270 - 340 ng/g
- Batch 0506644 : 360 ng/g
- Batch 44719/01 : < 50 ng/g
- Batch OpT 54 : 120 ng/g

3.1.6.Solubility

Soluble in water (5 g/100 ml) and in ethanol

Comment

Solubility in water has not been determined by EU Method A.6

3.1.7.Partition coefficient (Log Pow)

Log Pow: 2 (calculated)

Comment:

Log Pow has not been determined by EU method A.8

3.1.8.Additional physical and chemical specifications

Melting point: 215 °C

Boiling point: /

Flash point: /

Vapour pressure: /

Density: 0.35 g/cm³

Viscosity: /

pKa: /

Refractive index: /

3.1.9.Homogeneity and Stability

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 Solution/suspension of Hydroxyanthraquinone aminopropyl methyl morpholinium
 2 methosulfate in water at 10 mg/ml and 160 mg/ml were shown to be homogeneous
 3 (Coefficient of Variation of top, middle and bottom concentration was within 3%)

4
 5 Solution/suspension of Hydroxyanthraquinone aminopropyl methyl morpholinium
 6 methosulfate in water at 10 mg/ml and 160 mg/ml were shown to be stable up to 9 days
 7 (Coefficient of Variation of concentrations was within 10%)

8
 9 **General Comments to physico-chemical characterisation**

- 10
 11 • Hydroxyanthraquinone-aminopropyl methyl morpholinium methosulfate is a secondary
 12 amine, and thus, prone to nitrosation. The ATNC content (120-360 ppb NNO) in 3 of
 13 the 4 batches was higher than 50 ppb NNO. This indicates that the nitrosamine
 14 content in hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate may
 15 be > 50 ppb.
 16 - Solubility of Hydroxyanthraquinone-aminopropyl methyl morpholinium
 17 methosulfate has not been determined by EU Method A.6
 18 - The Log Pow strongly depends on the pH, especially for ionisable molecules,
 19 zwitterions etc. Therefore, a single calculated value of Log Pow, usually without
 20 any reference to the respective pH, cannot be correlated to physiological
 21 conditions and to the pH conditions of the percutaneous absorption studies.
 22 - Stability of hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate in
 23 typical hair dye formulations is not reported

24
 25 **3.2. Function and uses**

26
 27 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate is used in direct hair
 28 dye formulations at a maximum concentration of 0.5%.

30
 31 **3.3. Toxicological Evaluation**

32 **Taken from previous opinion (except mutagenicity, 3.3.6)**

34 **3.3.1. Acute toxicity**

36 **3.3.1.1. Acute oral toxicity**

38 Guideline: OECD 401
 39 Species/strain: Sprague-Dawley ICO:OFA-SD (IOPS Caw)
 40 Group size: 5 males + 5 females (2000, 1500 mg/kg bw), 5 females 1000 mg/kg bw
 41 Test substance: Imexine BD dissolved in distilled water
 42 Batch: op. T54
 43 Purity: 87.5%
 44 Dose: 1000, 1500, 2000 mg/kg bw by gavage
 45 GLP: in compliance

46
 47 Results

48 All females given 2000 mg/kg died within 30 minutes of dosing. 80% of the females (four
 49 animals) administered 1500 mg/kg died on days 1 and 2; 20% of those (one animal)
 50 administered 1000 mg/kg died on day 1. In males, mortality was 40% (two animals) on day
 51 1 at 2000 mg/kg and 80% (four animals) on day 1 at 1500 mg/kg. Males administered
 52 2000 mg/kg were observed to have tremors, hypo activity, sedation and dyspnoea, one in
 53 this group male had a purple-coloured tail from day 2 to day 15 of the study. Sedation and

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 hypo activity were observed in the males given 1500 mg/kg. Females at both 1500 and
2 1000 mg/kg showed signs of sedation, hypo activity, tremors, dyspnoea and piloerection.
3 Clinical signs were observed within 30 minutes of dosing. Recovery in surviving animals was
4 complete by day 2. No effect on body weight was observed. At necropsy, animals were
5 observed to have blue or purple discolouration of the gastrointestinal tract and sometimes of
6 the urinary bladder. With the exception of discolouration no abnormalities were observed at
7 necropsy. The body weight gain of the surviving animals was comparable to that of
8 historical controls.

9 Ref.: 1

10 SCCS Comment

11 The acute toxicity in rats is < 2000 mg/kg bw.

13 3.3.1.2. Acute dermal toxicity

14 No data submitted

17 3.3.1.3. Acute inhalation toxicity

18 No data submitted

19 20

21 3.3.2 Irritation and corrosivity

23 3.3.2.1. Skin irritation

25 Guideline: OECD 404
26 Species/strain: New Zealand White rabbits
27 Group size: 3 males
28 Test substance: Imexine BD
29 Batch: OpT 54 ; 87.5% active
30 Dose: 500 mg
31 GLP: in compliance
32 Date: 1995

33
34 A group of three male New Zealand White rabbits (mean body weight - 2.5 ± 0.2 kg) was
35 used. 500 mg Imexine BD (437.5 mg active dye) was applied in its original form to a
36 clipped area on the right flank and held in place for 4 hours under a semi-occlusive
37 dressing. The left flank served as a control. When the patches were removed, any residual
38 material was removed with distilled water. The skin was examined at 1, 24, 48 and 72
39 hours after removal of the dressing.

41 Results

42 There was no evidence of oedema at any of the patch test sites during the study. The
43 compound coloured the application sites, making assessment of erythema of grade 1 or
44 grade 2 impossible.

45 No erythema of grade 3 or grade 4 was noted. Because the grade of erythema could not be
46 determined, the compound could not be classified as to its irritant potential.

47 Ref.: 3

49 SCCS Comment

50 An irritant potential of neat Imexine BD could not be excluded due to skin staining.

51

52

53 3.3.2.2. Mucous membrane irritation

54 Guideline: OECD 405

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 Species/strain: New Zealand White rabbits
2 Group size: 3 males
3 Test substance: Imexine BD
4 Batch: OpT 54 ; 87.5% active
5 Dose: 100 mg
6 GLP: in compliance
7 Date: 1995
8
9

10 A group of three New Zealand White rabbits (mean body weight - 2.6 ± 0.2 kg) was used
11 for this study. 100 mg of Imexine BD in its original form (87.5 mg active dye) was placed
12 into the conjunctival sac of the left eye of the three rabbits. The upper and lower lids were
13 held closed for about 1 second to avoid any loss of the test substance. The eyes were not
14 rinsed after administration of the test substance. The untreated right eye of each animal
15 served as a control.

16 Evaluations of the conjunctiva, cornea and iris were made 1 hour after compound
17 administration, and at 1, 2 and 3 days thereafter.

18
19 Results

20 No signs of ocular irritation were observed during the study. Purple discolouration of the
21 conjunctiva was observed at the 1-hour observation time only. Imexine BD (87.5% active)
22 was non-irritant to the rabbit eye under the conditions of the study.

23 Ref.: 2
24

25 **3.3.3. Skin sensitisation**

26
27 **Guinea Pig Maximisation (Magnusson and Kligman)**

28
29 Guideline: OECD 406
30 Species/strain: Dunkin-Hartley guinea pigs
31 Group size: 10 females treated; 5 female controls
32 Test substance: Imexine BD
33 Batch: OpT 54 ; 87.5% active
34 Dose: Induction:intradermal 1% (0.875% active); epicutaneously 30%
35 Challenge:10% (8.75% active)
36 GLP: in compliance
37 Date: May 1995
38
39

40 A preliminary test was performed in two animals to determine the concentration to be used
41 in the principal study.

42 For the principal study, guinea pigs were allotted to two groups: a control group of five
43 females and a treated group of ten females. On day 1, six 0.1 ml intradermal injections
44 were administered (three on each side) in the scapular region: Freund's complete adjuvant
45 diluted to 50% (v/v) with sterile isotonic saline, a 1% concentration (w/w) of Imexine BD
46 (0.875% active dye) in sterile isotonic saline, and a mixture of 50/50 (w/v) Freund's
47 complete adjuvant in isotonic saline and 1% (w/w) Imexine BD (0.875% active dye) in the
48 vehicle.

49
50 In control animals, the vehicle replaced Imexine BD in the mixtures previously described.
51 On day 7, animals were treated with 10% sodium lauryl sulfate in petrolatum to induce local
52 irritation. On day 8, 0.5 ml of either the vehicle (control group) or a 30% (w/w)
53 concentration of the test substance (26.3% active dye) (treated group) was administered
54 topically in the area of the previous intradermal injections and held in place for 48 hours
55 under an occlusive dressing.

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 One hour after the dressings were removed, cutaneous reactions were recorded.
2

3
4 On day 22, a challenge dose of 0.5 ml of the vehicle was applied to the left flank and 0.5 ml
5 of a 10% (w/w) concentration of Imexine BD (8.75% active dye) in the vehicle was applied
6 to the right flank in both the control and treated groups. These treatments were left in place
7 for 24 hours under an occlusive dressing. Skin reactions were evaluated 24 and 48 hours
8 after removal of the occlusive dressing.
9

10 On day 25, the animals were killed and skin samples were taken from the application sites
11 on the right and left flanks for each animal. Tissues were preserved for possible microscopic
12 evaluation. Animals were judged to have positive reactions if lesions were clearly visible and
13 more marked than the most severe reaction in control animals or if "doubtful" reactions
14 were confirmed upon histopathological examination.
15

16 Results

17 After the challenge application, purple discolouration that could mask slight to well defined
18 erythema was observed in 3/10 treated animals at the 24-hour observation period. No
19 visible reactions were noted in the control group at any time. Very slight to severe
20 erythema was noted in 7/10 animals at 24 hours and in 9/10 animals at 48 hours. Slight
21 oedema was noted in 6/10 animals at 24 hours; none was observed at 48 hours. Crusts
22 were observed in 2/10 animals with severe erythema, and dryness of the skin was observed
23 in 6/10 guinea pigs at 48 hours.
24

25 Cutaneous reactions attributable to the sensitization potential of Imexine BD (87.5% active
26 dye) were observed in 9/10 guinea pigs.

Ref: 4

28 SCCS Comment

29 Imexine BD is a strong contact allergen.
30
31

32 Guinea Pig (Buehler)

33 Guideline: OECD 406

34 Species/strain: Dunkin-Hartley guinea pigs

35 Group size: 10 females + 10 males treated; 5 female + 5 male controls

36 Test substance: Imexine BD

37 Batch: OpT 54 ; 87.5% active

38 Dose: Induction: 0.5ml of 30% (26.3% active) on days 1, 8 and 15

39 1st Challenge: 0.5ml of 10% (8.75% active)

40 2nd Challenge: 0.5ml of 2% (1.8% active)

41 GLP: in compliance

42 Date: July 1995
43
44

45
46 Guinea pigs were allocated to two groups: a control group of five males and five females
47 and a treated group of ten males and ten females. During a 3-week induction period,
48 animals of the treated group received a cutaneous application of 0.5 ml of the test
49 substance at a concentration of 30% (w/w) (26.3% active dye) in distilled water on the
50 anterior left flank on days 1, 8 and 15 of the study. Control animals received the vehicle
51 (distilled water). Each application was held in place under an occlusive dressing for 6 hours.
52

53 After a 14-day rest period, 0.5 ml of the test substance at a concentration of 10% (w/w)
54 (8.75% active dye) in distilled water was applied on the posterior left flank and 0.5 ml of
55 the vehicle was applied on the posterior right flank (both previously untreated skin sites)
56 under occlusive dressing for 6 hours. Cutaneous reactions were evaluated 24, 48 and 72
57 hours after removal of the dressing.

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 A second challenge was performed and evaluated using this same method, but using the
2 test substance at a concentration of 2% (w/w) (1.8% active dye) on the left flank, with
3 sites being evaluated at 24 and 48 hours only.

4
5 Animals were judged to have positive reactions if macroscopic lesions were clearly visible
6 and more marked than the most severe reaction in control animals or if "doubtful"
7 macroscopic reactions were confirmed by histopathological examination.
8

9 Results

10 After the first challenge (10%), erythema was observed in one control animal at the 48-
11 hour observation point. Slight (incidence: 5/20) to well defined erythema (incidence: 2/20)
12 was observed in treated animals 24 hours after removal of the test substance. After 48
13 hours, slight erythema was observed in 6/20 animals (three of which had no erythema at 24
14 hours) and well defined erythema was observed in 3/20 animals (one of which had slight
15 erythema at 24 hours). After 72 hours, very slight erythema was noted in 9/20 animals,
16 and dryness of skin was noted in 3/20 animals.
17

18 No skin reactions were observed in either the control or the treated group after the second
19 challenge (2%).

20 Imexine BD (87.5% pure) at a concentration of 10% (8.75% active dye) elicited
21 sensitization reactions in 9/20 guinea pigs following induction with 30%. No reaction was
22 elicited upon rechallenge with a 2% dilution of the test compound (1.8% active dye).

23 Ref.: 5

24
25
26 **Guinea Pig (Buehler)**

27
28 Guideline: OECD 406
29 Species/strain: guinea pigs – Himalayan Spotted
30 Group size: 20 female treated; 10 female controls
31 Test substance: Imexine BD
32 Batch: OpT 54 ; purity 100%
33 Dose: Induction: 0.5ml of 10% on days 1, 8 and 15.
34 1st Challenge: 0.5ml of 3% on day 29
35 2nd Challenge: 0.5ml of 3% on day 43
36 GLP: in compliance
37 Date: May-July 1999
38
39

40 Each animal's fur was shaved with a fine clipper blade. 0.5 ml of freshly prepared test
41 article was applied to the skin in a 25 mm Hill Top Chamber, which was firmly secured with
42 an occlusive dressing and left in place for 6 hours.
43

44 For the induction phase of the study, fur was clipped from the left shoulder and 10%
45 Imexine BD in water was applied once a week for 3 weeks at the same site as described
46 above.
47

48 Skin responses were graded approximately 24 hours after the compound was removed. A 2-
49 week period elapsed prior to treatment with the challenge dose.
50

51 For the first challenge dose (day 29), fur was clipped from the left posterior side and back of
52 each animal of both the control and test groups. The challenge concentration of 3% Imexine
53 BD was applied for 6 hours on this naive skin site. Skin responses were graded at 24 and 48
54 hours after removal of the test compound.
55

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 For the second challenge dose (day 43), fur was clipped from the right posterior side and
2 back of each animal. The rechallenge concentration of 3% Imexine BD was applied for 6
3 hours on this naive skin site. Only the test group was rechallenged. Skin responses were
4 graded at 24 and 48 hours after removal of the test compound.

5 **Results**

6 One animal was found dead on day 23; no abnormal findings were noted at necropsy. The
7 cause of death could not be established.

8 After induction, no oedema was noted. Discoloration of the application site precluded the
9 evaluation of erythema.

10 At first challenge, discrete/patchy to moderate/confluent erythema was observed in 2/19
11 treated animals at the 24- and 48-hour readings. Discrete/patchy erythema was observed in
12 an additional treated animal at 48 hours. No reactions were observed in control animals.

13 At rechallenge, discrete/patchy to moderate/confluent erythema was observed in 7/19
14 treated animals at the 24-hour reading and in 9/19 treated animals at the 48-hour reading.
15 A concentration of 3% Imexine, BD elicited allergic reactions following induction with 10%.

16 The substance was considered to be sensitizing in this study.

17 Ref.: 6

18 **SCCS Comment**

19 The study report states that Imexine BD batch OpT 54 was 100% pure. However, other
20 reports indicate that batch OpT 54 (or similarly described) was 87.5% active.

21 **Guinea Pig (Buehler)**

22 Guideline: OECD 406
23 Species/strain: guinea pigs – Himalayan Spotted
24 Group size: 20 female treated; 10 female controls
25 Test substance: Imexine BD
26 Batch: OpT 54 ; 87.5% active
27 Dose: Induction: 0.5ml of 5% (4.4% active) on days 1, 8 and 15.
28 Challenge: 0.5ml of 1% on day 29
29 GLP: in compliance
30 Date: Aug-Sept 1999

31 The same patching method was used for the induction and challenge phases of the study.
32 Each animal's fur was shaved with a fine clipper blade. 0.5 ml of freshly prepared test
33 article was applied to the skin in a 25 mm Hill Top Chamber, which was firmly secured with
34 an occlusive dressing and left in place for 6 hours.

35 For the induction phase of the study, fur was clipped from the left shoulder and 5% Imexine
36 BD (4.4% active dye) in water was applied once a week for three weeks at the same site as
37 described above. Skin responses were graded approximately 24 hours after the compound
38 was removed. Challenge was 2-week later.

39 For the challenge dose (day 29), fur was clipped from the left posterior side and back of
40 each animal of both the control and test groups. The challenge concentration of 1% Imexine
41 BD (0.875% active dye) was applied for 6 hours on this naive skin site. Skin responses were
42 graded at 24 and 48 hours after removal of the test compound.

43 **Results**

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 After induction, discolouration of the application site precluded the evaluation of erythema.
2 No oedema was noted.
3
4 No skin reactions were observed in either control or treated animals after challenge with the
5 concentration of 1% Imexine BD.
6
7 The concentration of 1% Imexine BD (87.5% active dye) did not elicit allergic reactions
8 following induction with 5% of the substance
9 Ref.: 7
10 SCCS comment on sensitising potential
11 Imexine BD is a strong skin sensitisier.
12
13

14 **3.3.4. Dermal / percutaneous absorption**

15
16 ***In Vitro Percutaneous Absorption Study using Human Dermatomed Skin***

17
18 Guideline: /
19 Species/strain: human dermatomed abdominal skin; $465 \pm 97 \mu\text{m}$
20 Group size: 4 donors; 2 samples from each donor
21 Integrity: Trans epidermal water loss (TEWL)
22 Chamber: Flow through diffusion cells
23 Test substance: Imexine BD 0.5% in hair dye formulation 175325 (= 0.5% Imexine BD;
24 2.5% Benzyl alcohol; 10% Deceth 5; 4.0% Propylene glycol; 83.0%
25 aqua)
26 Batch: OpT 54 ; purity 87.5 %
27 Stability in formulation: 0.8% loss after 1 week
28 Application: 20 mg/cm²
29 Receptor fluid: Physiological saline
30 Solubility in receptor fluid: > 71 µg/ml
31 Detection: HPLC
32 GLP: in compliance
33 Date: December 1999
34
35

36 Human skin samples from four donors were obtained from abdominal plastic surgery. They
37 were transported at 4°C and kept frozen at -20°C until they were used.
38 Two dermatomed skin samples per donor were used.

39
40 Twenty (20) mg/cm² of a hair dye formulation 175325 containing 0.50% (w/w) Imexine BD
41 (equivalent to $98.5 \pm 1.0 \mu\text{g}/\text{cm}^2$ Imexine BD), were applied to the skin surface for 30
42 minutes.

43
44 After 30 minutes, any of the hair dye formulation 175325 remaining on the skin was
45 removed using a standardized washing procedure. Twenty-four (24) hours after application,
46 the percutaneous penetration of Imexine BD was determined by measuring the
47 concentration of the compound by HPLC and UV-Visible detection in the following
48 compartments: skin excess, stratum corneum, epidermis + dermis, and receptor fluid.

49
50 Results
51 Seven of the eight samples tested yielded data that could be used. Most of the hair dye
52 remaining on the skin after the application period was removed in the washing procedure.

53
54 The cutaneous distribution of Imexine BD (mean \pm SD) was as follows:
55
56

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

Skin excess µg/cm ² % of the applied dose	102.09 ± 2.33 103.62 ± 2.39
Stratum corneum µg/cm ² % of the applied dose	1.50 ± 0.36 1.52 ± 0.36
Epidermis + dermis µg/cm ² % of the applied dose	0.86 ± 0.34 0.87 ± 0.34
Receptor fluid µg/cm ² % of the applied dose	0.083 ± 0.025 0.085 ± 0.027
Total recovery % of the applied dose	106.0 ± 2.1

1 The absorbed amount (epidermis + dermis + receptor fluid) was 0.90 ± 0.31% of the
 2 applied dose (or 0.89 ± 0.31 µg/cm²).
 3

Ref.: 17

4
 5 SCCS Comment
 6 As this study was non-guideline, the amount considered absorbed for calculating the MOS is
 7 mean + 2SD. This is 1.52% of the applied dose or 1.51 µg/cm².
 8

9 **3.3.5. Repeated dose toxicity**

10 **3.3.5.1. Repeated Dose (28 days) oral toxicity**

11 No data submitted
 12
 13

14 **3.3.5.2. Sub-chronic (90 days) toxicity (oral, dermal)**

15 **Dose range finding study (2 weeks)**

16
 17 Guideline: /
 18 Species/strain: Sprague-Dawley rats Crl CD (SD) BR
 19 Group size: 6 males + 6 females
 20 Test substance: Imexine BD suspended in water for injection
 21 Batch: OpT 54
 22 Purity: 87.5%
 23 Dose: 0, 50, 200, 800 mg/kg bw/day by gavage
 24 GLP: in compliance
 25
 26

27 The study protocol was similar to the OECD 407.

28 At 800 mg/kg/day ptalism, pink coloured urine, blue coloured faeces and purple coloured
 29 body extremities were noted. No mortalities occurred. Food consumption and body weight
 30 gain were similar to the controls. Slightly lower neutrophil and monocyte counts in females
 31 and slightly higher glucose levels in males were noted at 800 mg/kg bw per day. With the
 32 exception of discolouration of some organs no relevant macroscopic as well as microscopic
 33 findings were reported. The same doses were chosen for the main study.
 34

Ref.: 8

35
 36 **Main study (13 weeks)**
 37
 38

39
 40 Guideline: OECD 408 (1981)
 41 Species/strain: Sprague-Dawley rats Crl CD (SD) BR
 42 Group size: 10 males + 10 females
 43 Test substance: Imexine BD suspended in water
 44 Batch: OpT 54

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 Purity: 87.5%
2 Dose: 0, 50, 200, 800 mg/kg bw by gavage
3 GLP: in compliance

4
5 Three groups of 10 male and 10 female rats received Imexine BD daily by gavage at 50,
6 200, 800 mg/kg bw/day for 13 weeks, a further group treated with water served as control.
7 A recovery group was not included. The animals were checked daily for clinical signs and
8 mortality. Body weight and food consumption were recorded once per week.
9 Ophthalmological examinations were performed before treatment, and on week 13 in the
10 control and the high dose group. Haematology, blood biochemistry and urinalysis were
11 determined in week 13. At the end of the treatment period the animals were sacrificed,
12 macroscopically examined and organs were weighed. Microscopic examination was
13 performed on the control and the high dose group animals and all animals with macroscopic
14 lesions.

15
16 Results

17 No substance-related mortality was observed. Discolouration of tail, fur, extremities, urine
18 and faeces was observed in animals of the high dose and (partially) in the 200 mg/kg dose.
19 All further clinical signs were judged as not being substance-related. The findings on food
20 consumption and ophthalmoscopy were not considered treatment-related. The body weight
21 of the males in the 200 and 800 mg/kg bw/d groups was decreased (weight change
22 compared with controls -15 %) as well as the thymus weight of females (absolute and
23 relative) and males (absolute) at 800 mg/kg bw/d. A statistically significant dose-related
24 decrease in the number of monocytes of males was found at 800 mg/kg bw/d while
25 biochemistry and urinalysis values were not changed. The microscopic pathology findings
26 revealed no substance-related effects.

27 The NOAEL is 200 mg/kg bw/d.

28 Ref.: 9

29
30 SCCS comment

31 The SCCS considers 50 mg/kg bw/d as the NOAEL due to bw reduction in the middle dose.

32 3.3.5.3. Chronic (> 12 months) toxicity

33
34 No data submitted

35
36 3.3.6. Mutagenicity / Genotoxicity

37
38 3.3.6.1 Mutagenicity / Genotoxicity *in vitro*

39
40 Bacterial gene mutation assay

41
42 Guideline: OECD 471 (1994)
43 Species/strain: *S. typhimurium*, TA98, TA100, TA102, TA1535, TA1537; *E. coli*,
44 WP2uvrA
45 Replicates: Triplicates in two independent tests
46 Test substance: IMEXINE BD
47 Batch: op. T54
48 Purity: 87.5%
49 Solvent: distilled water
50 Concentrations: experiment I: 312.5, 625, 1250 and 2500 µg/plate without S9-mix
51 125, 250, 500, 1000 and 2000 µg/plate with S9-mix
52 experiment II: 312.5, 625, 1250 and 2500 µg/plate without S9-mix
53 62.5, 125, 250, 500 and 1000 µg/plate with S9-mix
54 Treatment: experiment I: direct plate incorporation method with 48-72 h
55 incubation without and with S9-mix

experiment II: direct plate incorporation method with 48 – 72 h incubation without S9-mix
pre-incubation method with 60 minutes pre-incubation and 48 – 72 h incubation with S9-mix

GLP: in compliance
Study period: June 1995

IMEXINE BD has been investigated for the induction of gene mutation in *Salmonella typhimurium* and *Escherichia coli*. Liver S9 fraction from rats induced with Aroclor was used as the exogenous metabolic activation system. Test concentrations were based on the level of toxicity in a preliminary toxicity test with TA98 and TA100 both without and with S9-mix. Toxicity was evaluated for 6 concentrations up to the prescribed maximum concentration of 5000 µg/plate on the basis of a reduction in the number of spontaneous revertant colonies and/or clearing of the bacterial background lawn. Experiment I and experiment II without S9-mix was performed with the direct plate incorporation method, experiment II with S9-mix with the pre-incubation method with 60 min pre-incubation. Negative and positive controls were in accordance with the OECD guideline.

Results

In the preliminary toxicity study no substantial toxicity was found in the absence of S9-mix and therefore the concentration range was based on the recommended maximum of 5000 µg/plate. In the presence of S9-mix a decrease in the number of revertants was observed at concentrations > 1000 µg/plate. Therefore, the maximum concentration chosen was 2000 µg/plate in the first test (direct plate incorporation) and 1000 µg/plate in the second test (preincubation method).

15 (pronunciation method).
26 A biologically relevant and concentration-dependent increase in the number of revertants
27 was found in TA100 and TA102 with S9-mix only and in TA1537 and in TA98 both without
28 and with S9-mix. IMEXINE BD did not induce a biologically relevant increase in the number
29 of revertants in experiments with the *E.coli* strain WP2uvrA and *S. typhimurium* strain TA
30 1535.

Conclusion

Under the experimental conditions used IMEXINE BD was mutagenic in this gene mutation tests in bacteria.

Ref.: 10

Bacterial gene mutation assay

39
40 Guideline: OECD 471 (1997)
41 Species/strain: *S. typhimurium*, TA98, TA100, TA102, TA1535, TA1537
42 Replicates: triplicate cultures in two independent experiments
43 Test substance: hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate
44 Batch: 0508813
45 Purity: 94.5%
46 Solvent: DMSO
47 Concentrations: experiment I: 0.064, 0.32, 1.6, 8, 40, 200 and 1000 µg/plate
48 without S9-mix
49 0.32, 1.6, 8, 40, 200, 1000 and 5000 µg/plate with
50 S9-mix
51 experiment II 20.48, 51.2, 128, 320, 800, 2000 and 5000 µg/plate
52 without and with S9-mix
53 Treatment: direct plate incorporation method with 72 h incubation without and
54 with S9-mix
55 GLP: in compliance
56 Study period: 11 December 2003 – 30 January 2004
57

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate was investigated for
2 the induction of gene mutations in *Salmonella typhimurium* strains (Ames test). Liver S9
3 fraction from Aroclor 1254-induced rats was used as exogenous metabolic activation
4 system. Test concentrations were based on the level of toxicity in toxicity range-finder
5 experiment with TA100 both without and with S9-mix. Toxicity was evaluated for 6
6 concentrations up to the prescribed maximum concentration of 5000 µg/plate on the basis
7 of a reduction in the number of spontaneous revertant colonies and/or clearing of the
8 bacterial background lawn. The range finder and both main experiments were performed
9 with the pre-incubation method. The results from the TA100 treatments were included in
10 experiment I. Negative and positive controls were in accordance with the guideline.

11 **Results**

12 In the initial range finder, complete killing of the test bacteria was observed following the
13 top concentration both in the absence and presence of S9-mix. Further evidence of toxicity
14 in the form of a marked decrease in the number of spontaneous revertant colonies was
15 observed after 1000 µg/plate in the absence of S9-mix.

16 In the experiment I, complete killing was observed in TA98, TA100, TA1537 and TA102
17 without S9-mix following the top concentration but not in TA1535; with S9-mix in TA98,
18 TA100, TA1537 and TA102 but not in TA1535 and 1537. In experiment II toxicity was
19 observed following the top one or two concentrations in most strains both without (not in
20 TA1535) and with (not in TA1537) S9 metabolic activation.

21 Concentration dependent and statistically significant increases in the number of revertants
22 were found in TA102 (experiment I only) and TA1537 without S9-mix and in TA98, TA100
23 (experiment II only) and TA102 with S9-mix.

24 **Conclusion**

25 Under the experimental conditions used, hydroxyanthraquinone aminopropyl methyl
26 morpholinium methosulfate was mutagenic in this gene mutation tests in bacteria.

27 Ref.: 2 Subm II

28 **Gene mutation test in mammalian cells (*tk* locus)**

29
30
31
32
33
34 Guideline: OECD 476
35 Cells: L5178Y mouse lymphoma cells *tk*⁺⁻
36 Replicates: duplicate cultures in two independent tests
37 Test substance: IMEXINE BD
38 Batch: opT 54
39 Solvent: distilled water
40 Purity: 87.5%
41 Concentrations: 500, 1000, 2000, 3000 and 4000 µg/ml in experiment I without and
42 with S9-mix and in experiment II without S9-mix.
43 187.5, 375, 750, 1500 and 300 µg/ml in experiment II with S9-mix
44 Treatment 3 h both without and with S9 mix; expression period 2 days and a
45 selection period of 10 ± 1 days.
46 GLP: in compliance
47 Study period: 13 April 1995 – 5 September 1995
48

49 IMEXINE BD has been investigated for induction of gene mutations at the *tk*-locus in L5178Y
50 mouse lymphoma cells after exposure for 3 hours without and with metabolic activation.
51 Liver S9 fraction from Aroclor 1254-induced rats was used as the exogenous metabolic
52 activation system. Test concentrations were based on the results of a preliminary toxicity
53 test with 6 concentrations up to the prescribed maximum concentration of 5000 µg/ml
54 measuring survival relative to the concurrent vehicle control cell cultures.

55 In the main test, cells were treated for 3 h followed by an expression period of 2 days to fix
56 the DNA damage into a stable *tk* mutation. To discriminate between large (indicative for

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 mutagenic effects) and small colonies (indicative for a clastogenic effect) colony seizing was
2 performed. Negative and positive controls were in accordance with the OECD guideline.
3

4 **Results**

5 Both in the absence and presence of S9-mix the appropriate level of toxicity (10-20%
6 survival after the highest dose) was not reached.

7 In the first experiment without S9-mix a biological increase in the relative mutant frequency
8 was not observed despite an increase in the absolute mutant frequency, obviously due to a
9 reduced cloning efficiency in the vehicle control. In the second experiment without S9-mix,
10 a statistically significant and concentration-related increase in the mutant frequency was
11 measured. In the first test with S9-mix a statistically significant and concentration-
12 dependent increase in the mutant frequency was obtained while in the second experiment
13 the increase in mutant frequency was less obvious and not higher than a doubling of the
14 control value. An increased number of small colonies was observed in all experiments.
15

16 **Conclusion**

17 Under the experimental conditions used, IMEXINE BD was mutagenic in this mouse
18 lymphoma assay at the *tk* locus.

19 Ref.: 12

20 **SCCS Comment**

21 The finding of an increased number of small colonies in all experiments may indicate to a
22 clastogenic next to a mutagenic effect of IMEXINE BD in this mouse lymphoma assay.
23

24 **Gene mutation test in mammalian cells (*hprt* locus)**

25 Guideline: OECD 476 (1997)
26 Cells: L5178Y mouse lymphoma cells
27 Replicates: duplicate cultures in two independent tests
28 Test substance: hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate
29 Batch: 0508813
30 Solvent: DMSO
31 Purity: 94.5%
32 Concentrations: experiment I: 250, 500, 600, 700, 800, 900, 1000 and 1100
33 µg/ml without and with S9-mix
34 experiment II: 100, 250, 400, 500, 600, 700, 800, 900, 1000 and
35 1100 µg/ml without and with S9-mix
36 Treatment: 3 h both without and with S9-mix; expression period 7 days and a
37 selection period of 11-12 days.
38 GLP: in compliance
39 Study period: 4 December 2003 – 26 January 2004
40

41 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate was assayed for
42 gene mutations at the *hprt* locus of mouse lymphoma cells both in the absence and
43 presence of metabolic activation. Liver S9 fraction from Arachlor 1254-induced rats was
44 used as exogenous metabolic activation system. Test concentrations were based on the
45 results of a cytotoxicity range-finding experiment measuring relative survival with 6
46 concentrations up to the maximum concentration of 2000 µg/ml. In the main tests, cells
47 were treated for 3 h followed by an expression period of 7 days to fix the DNA damage into
48 a stable *hprt* mutation. Toxicity was measured as percentage survival of the treated cultures
49 relative to the survival of the solvent control cultures. Negative and positive controls were in
50 accordance with the OECD guideline.
51

52 **Results**

53 In the cytotoxicity range-finder experiment, precipitation and extreme cytotoxicity (10%
54 relative survival) was observed at the two highest concentrations (1000 and 2000 µg/ml)
55 both without and with S9-mix after the 3 h exposure period. The highest concentration to
56

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

give > 10% relative survival (500 µg/ml) yielded 44% and 46% relative survival without and with S9-mix, respectively. In experiment I the highest concentrations analysed were 900 µg/ml without S9-mix and 1000 µg/ml with S9-mix giving 14 and 13% relative survival, respectively; in experiment II 1000 µg/ml without S9-mix and 1100 µg/ml with S9-mix giving 13 and 16% relative survival.

In experiment I in the presence of S9-mix occasionally statistically significant increases in the mutant frequency were observed. However, the mutant frequencies were predominantly within the range of the historical controls. As a biologically relevant increase in the mutant frequency was not found in experiment II in the presence of S9-mix, the positive results could of experiment I could not be reproduced in experiment II and, consequently, were considered as not biologically relevant.

No biological relevant increases in mutant frequencies were observed following treatment with hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate at any dose level tested, in the absence of S9-mix in both experiments.

Conclusion
Under the experimental conditions used, hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate was considered not mutagenic in this gene mutation test in mammalian cells at the *hprt* locus.

Ref.: 3 Subm II

Chromosome aberration test in mammalian cells

Guideline:	OECD 473 (1994)
Cells:	Chinese hamster ovary (CHO) cells
Replicates:	duplicate cultures in 2 independent tests
Test substance:	IMEXINE BD
Batch:	op T54
Solvent:	distilled water
Purity:	87.5%
Concentrations:	experiment I: 50, 150, and 500 µg/ml without S9-mix 500, 1500 and 5000 µg/ml with S9-mix experiment II: 125, 250 and 500 µg/ml without S9-mix (20 h) 1250, 2500 and 5000 µg/ml with S9-mix (20 h) 125, 250 and 375 µg/ml without S9-mix (44 h) 1250, 2500 and 5000 µg/ml with S9-mix (44 h)
Treatment:	experiment I: 20 h treatment and harvest time 20 h after start of treatment without S9-mix 3 h treatment and harvest time 20 h after start of treatment without S9-mix experiment II: 20 h treatment and harvest time 20 h after start of treatment without S9-mix 3 h treatment and harvest time 20 h after start of treatment without S9-mix 44 h treatment and harvest time 44 h after start of treatment without S9-mix 3 h treatment and harvest time 44 h after start of treatment without S9-mix
GLP:	in compliance
Study period:	24 January 1995 – 19 April 1995

IMEXINE BD has been investigated for induction of chromosomal aberrations in CHO cells. Liver S9 fraction from Aroclor1254-induced rats was used as the exogenous metabolic activation system. IMEXINE BD was freely soluble in distilled water at 150 mg/ml expressed in active material. Up to the prescribed maximum concentration of 5000 µg/ml, no

1 precipitation was observed. Therefore, in the first experiment both with and without S9-mix
2 6 concentrations were used up to 5000 µg/ml. Next to 2 lower concentrations, the top
3 concentrations for scoring were based upon a 38-65% reduction in the mitotic index. In the
4 different experiments, cells were treated continuously for 20 or 44 h and harvested
5 immediately after the end of treatment or for 3 h and harvested 20 or 44 h after the start of
6 treatment. Approximately 1.5 h before harvest, each culture was treated with colcemid to
7 block cells at metaphase of mitosis. Negative and positive controls were in accordance with
8 the OECD guideline.

9
10 **Results**

11 In the experiments with a harvest time of 20 h the required reduction in mitotic index was
12 found but not in the experiments with a harvest time of 44 h.

13 The test substance induced a statistically significant and concentration dependent increase
14 in the number of cells with chromosome aberrations in all experiments with and without S9-
15 mix at both harvest times.

16
17 **Conclusion**

18 Under the experimental conditions used, IMEXINE BD was considered genotoxic
19 (clastogenic) in this chromosome aberration test in mammalian cells (CHO cells).

20 Ref.: 11
21
22

23 **Chromosome aberration test in human peripheral blood lymphocytes**

24
25 Guideline: OECD 473 (1997)
26 Species/Strain: Human peripheral lymphocytes from three healthy female donors
27 Replicates: duplicate cultures in 2 independent experiments
28 Test substance: hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate
29 Batch: 0508813
30 Solvent: DMSO
31 Purity: 94.5%
32 Concentrations: experiment 1: 103.1, 161.1 and 251.7 µg/ml without S9-mix
33 52.79, 103.1 and 251.7 µg/ml with S9-mix
34 experiment 2: 72.54, 100.4 and 118.1 µg/ml without S9-mix
35 118.1, 139.0 and 226.3 µg/ml with S9-mix
36 Treatment experiment 1: 3 h treatment without and with S9-mix; harvest time
37 20 h after the start of treatment
38 experiment 2: 20 h treatment without S9-mix; harvest time 20 h
39 after start of treatment.
40 3 h treatment with S9-mix; harvest time 20 h after
41 start of treatment.
42 GLP: in compliance
43 Study period: 9 December 2003 – 4 February 2004
44

45 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate has been
46 investigated for the induction of chromosomal aberrations in human lymphocytes of 3
47 healthy non-smoking female donors both in the absence and presence of metabolic
48 activation. Liver S9-fraction from Aroclor 1254-induced rats was used as exogenous
49 metabolic activation system. In both experiments for both harvest times and in the absence
50 and presence of S9-mix, human lymphocytes were exposed to various concentrations of
51 hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate. The concentrations
52 for chromosome analysis were selected on the basis of the effect of hydroxyanthraquinone
53 aminopropyl methyl morpholinium methosulfate on the mitotic index. Chromosome
54 aberrations were analysed at 3 concentrations, the highest concentration inducing
55 approximately 55% mitotic inhibition.

56 Cells were treated for 3 h (without and with S9-mix) or 20 h (without S9-mix) and
57 harvested 20 h after the start of treatment. Approximately 2 h before harvest, each culture

1 was treated with colcemid (1 µg/ml culture medium) to block cells at metaphase of mitosis.
2 Negative and positive controls were in accordance with the OECD guideline.

3 **Results**

4 Although after 3 h treatment in the absence S9-mix an increase in the number of cells with
5 chromosomal aberrations was found at the highest concentration tested, a biologically
6 relevant and concentration dependent increase in the number of cells with chromosome
7 aberrations was not found.

8 Statistically significant and concentration dependent increases in the number of cells with
9 chromosomal aberrations compared to the concurrent negative controls and the historical
10 negative control range were found for both experiments with S9-mix and after 20 h
11 exposure without S9-mix.

12 Increases in the number of cells with numerical aberrations, that exceeded the concurrent
13 controls and the historical negative control range, were found in experiment 1 in the
14 presence of S9-mix at the highest concentration tested. As these findings were not
15 reproduced in experiment 2 and not found in the experiments without S9-mix, they were
16 considered not biologically relevant.

17 **Conclusion**

18 Under the experimental conditions used, hydroxyanthraquinone aminopropyl methyl
19 morpholinium methosulfate was genotoxic (clastogenic) in this chromosome aberration test
20 in human lymphocytes.

21 Ref.: 4 Subm II

22 **3.3.6.2 Mutagenicity / Genotoxicity *in vivo***

23 **Mouse bone marrow micronucleus test**

24 Guideline: OECD 474
25 Species/strain: Mouse, Swiss OF1/ICO:OF1 (IOPS Caw)
26 Group size: 5 mice/sex/group
27 Test substance: IMEXINE BD
28 Batch: op. T54
29 Purity: 87.5%
30 Vehicle: distilled water
31 Dose levels: 0, 500, 1000 and 2000 mg/kg bw/day
32 Route: orally, twice at 24h interval
33 Sacrifice times: 24 h after treatment the last treatment
34 GLP: in compliance
35 Study period: 6 November 1995 – 30 April 1996

36 IMEXINE BD has been investigated for induction of micronuclei in bone marrow cells of
37 mice. Test doses were based on the results of a preliminary toxicity test on a group of 3
38 male and 3 female mice recording clinical signs and mortality for a period of 48 h performed
39 under identical conditions as in the main study.

40 In the main experiment male and female mice were exposed orally twice at 24 h intervals to
41 0, 500, 1000, 2000 mg/kg bw/day. The mice were examined for acute toxic symptoms
42 and/or mortality. Bone marrow cells were collected 24 h after the last treatment. For each
43 mouse the percentage of polychromatic erythrocytes with a micronucleus was counted in
44 2000 polychromatic erythrocytes. In addition, for each mouse of the vehicle control and the
45 highest dose group an additional 2000 polychromatic erythrocytes will be counted. Toxicity
46 and thus exposure of the target cells was determined by measuring the ratio between
47 polychromatic and normochromatric erythrocytes (PCE/NCE). Negative and positive controls
48 were in accordance with the OECD guideline.

49
50
51
52
53
54
55
56
57

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

Results

Since in the preliminary toxicity tests no toxic effects were observed, 2000 mg/kg bw was selected as the top dose-level.

One female mouse of the 2000 mg/kg bw/day group was found dead 2 h after the last treatment. No other mortality was observed. No clinical signs were observed in the mice of both sexes in any group. In all treated groups, the PCE/NCE ratio was lower than in the negative control group indicating toxicity to the bone marrow and relevant exposure of the target cells.

In the groups treated with 500 and 2000 mg/kg bw/day an increase in the number of polychromatic erythrocytes with micronuclei was observed compared to the untreated control group. However, the mean MNPCE frequencies were not statistically significantly increased in any of the groups treated with the test substance. Moreover, the findings were always within the range of the historical negative control values.

Conclusions

Under the experimental conditions used IMEXINE BD did not induce an increase in the number of bone marrow cells with micronuclei and, consequently, IMEXINE BD is not genotoxic (clastogenic and/or aneugenic) in bone marrow cells of mice.

Ref.: 13

SCCS Comment

Only the average numbers of bone marrow with micronuclei per group are reported and not the individual data per mouse. The lack of the individual data per mouse diminishes the value of the test.

Unscheduled DNA Synthesis (UDS) Test

Guideline: draft OECD 486 (1991)
Species/strain: rat, Wistar HanIbm: WIST (SPF)
Group size: 4 male rats/group
Test substance: Imexine BD in
Batch No.: Op T54
Purity: 87.5%
Vehicle: deionised water
Dose levels: 0, 200 and 2000 mg/kg bw
Route: orally by gavage
Sacrifice times: 2 (high dose group only) and 16 hours
GLP: in compliance
Study period: 10 July 1997 – 7 October 1997

Imexine BD was investigated for the induction of unscheduled DNA synthesis (UDS) in hepatocytes of rats. Test doses were based on a pre-experiment for toxicity, using the same conditions as in the UDS test, measuring acute toxic symptoms at intervals of 1 h and 24 h after oral administration of 2000 mg/kg bw. In the main experiment the rats were treated with 0, 200 and 2000 mg/kg bw once by oral gavage. The animals were starved before treatment.

Hepatocytes for UDS analysis were collected by perfusion with 0.05% w/v collagenase approximately 2 h (high dose only) and 16 h after administration of Imexine BD. The quality of the actual performed perfusion was determined by the trypan blue dye exclusion method. At least 3 cultures were established for each animal. At least 90 minutes after plating the cells were incubated for 4 h with 5 µCi/ml ³H-thymidine (specific activity 20 Ci/mmol) followed by overnight incubation with unlabelled thymidine. Evaluation of autoradiography was done after 15 days.

The number of grains in a nuclear area and the number in one nuclear-sized cytoplasmic area adjacent to this nucleus was counted. At least 2 slides per rat and 50 cells per slide were evaluated. The mean nuclear and cytoplasmic grain counts as well as the mean net grain counts (nuclear minus cytoplasmic grain count) were reported separately.

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 Negative and positive controls were in accordance with the OECD guideline.

2 **Results**

3 In the pre-experiment for toxicity at 2000 mg/kg bw both rats showed apathy 1 h and
4 excitement 24 h after treatment. For both rats violet colored urine was reported at 24 h.

5 The viability of the hepatocytes determined by means of the trypan blue dye exclusion
6 assay was not substantially affected by the treatment and was in the range of the historical
7 laboratory control data.

8 A biological relevant increase in mean net nuclear grain count as compared to the untreated
9 control was not found in hepatocytes of any treated animal both for the 2 h and the 16 h
10 treatment time.

11 **Conclusions**

12 Under the experimental conditions used, Imexine BD did not induce unscheduled DNA
13 synthesis and, consequently, is not genotoxic in rats in the *in vivo* UDS test.

14 Ref.: 14

15 **Unscheduled DNA Synthesis (UDS) Test**

16 Guideline: draft OECD 486

17 Species/strain: rat, Crl:CD[®](SD)IGS BR

18 Group size: 4 male rats/group

19 Test substance: hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate

20 Batch: 0508813

21 Vehicle: water

22 Purity: 94.5%

23 Dose level: 0, 500, 1000 and 2000 mg/kg bw

24 Route: oral gavage

25 Sacrifice times: 2- 4 h and 14-16 h after dosing

26 GLP: in compliance

27 Study period: 18 November 2003 – 4 February 2004

28 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate was investigated for
29 the induction of unscheduled DNA synthesis (UDS) in hepatocytes of rats. Test doses were
30 based on a dose range finding study for toxic symptoms and/or mortality. Five groups of 3
31 rats were treated orally with doses ranging from 270 up to 2160 mg/kg bw and were
32 observed at intervals of 1, 2 and 4 h and daily after treatment. In the main experiment the
33 rats were treated with 0, 500, 1000 and 2000 mg/kg bw once by oral gavage.

34 Hepatocytes for UDS analysis were collected by perfusion with HBBS/EGTA followed by
35 WMEC. 2-4 and 14-16 h after administration of hydroxyanthraquinone aminopropyl methyl
36 morpholinium methosulfate. The hepatocytes were obtained by mechanical dispersion of
37 excised liver tissue. After an attachment period of 1.5 to 2 h after plating the cells were
38 incubated for 4 h with 10 µCi/ml ³H-thymidine (specific activity 40-60 Ci/mmol) followed by
39 overnight incubation with unlabelled thymidine. Evaluation of autoradiography was done
40 after 8 days.

41 UDS was reported as net grains per nucleus: the nuclear grain count subtracted with the
42 average number of grains of 3 nuclear-sized areas adjacent to each nucleus. Unscheduled
43 synthesis was determined in 50 randomly selected hepatocytes on 3 replicate slides per rat.
44 Negative and positive controls were in accordance with the OECD guideline.

45 **Results**

46 In the dose range finder study for toxicity, 2 rats showed purple stain at the front feet (540
47 mg/kg bw), 3 rats showed purple stain at all feet (1080 and 2160 mg/kg bw) and all rats
48 treated with doses of 1080 mg/kg bw and above showed discoloured black faeces. In the
49 rats which were sacrificed 2-4 h after treatment, all rats showed purple stain at the front
50 feet. The rats of the 14-16 sacrifice groups had purple stain at the front or front feet (500

1 and 2000 mg/kg bw), discoloured black faeces (500 and 1000 mg/kg bw) or soft faeces,
2 dark orange genital discharge of black faeces (2000 mg/kg bw). The viability of the isolated
3 hepatocytes ranged from 70 – 100%.

4 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate did not cause any
5 biological relevant or statistically significant changes in the degree of nuclear labelling of
6 cultured hepatocytes after treatment of male rats, whether assayed at 2-4 or 14-16 h after
7 treatment.

8
9 Conclusions
10 Under the experimental conditions used, hydroxyanthraquinone aminopropyl methyl
11 morpholinium methosulfate did not induce unscheduled DNA synthesis and, consequently, is
12 not genotoxic in rats in the *in vivo* UDS test. Ref.: 14

Under the experimental conditions used, hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate did not induce unscheduled DNA synthesis and, consequently, is not genotoxic in rats in the *in vivo* UDS test. Ref.: 14

Ref.: 14

3.3.7. Carcinogenicity

No data submitted

3.3.8. Reproductive toxicity

3.3.8.1. Two generation reproduction toxicity

No data submitted

3.3.8.2. Teratogenicity

Guideline: /
Species/strain: Sprague-Dawley rats Crl CD (SD) BR
Group size: 7 mated females
Test substance: Imexine BD suspended in water
Batch: OpT 54
Purity: 87.5 %
Dose: 0, 50, 200, 800 mg/kg bw by gavage
GLP: not in compliance

The pregnant animals were treated daily by gavage from day 6 to 15 of gestation. Clinical signs including mortality were checked daily. Food consumption was recorded from days 2-6, 6-9, 12-15, and 15-20 of gestation. Body weights were recorded on days 2, 6, 9, 12, 15, and 20 of gestation. On day 20 the dams were sacrificed, the foetuses were removed by Caesarean section and the number of implantations was determined. The foetuses were weighed, checked for external abnormalities and sexed.

Results

No mortality and no clinical signs with the exception of Ptyalism and some discolouration were observed in the 800 mg/kg bw dose group. No changes in food consumption and body weight gain were noted. The resorption rate, mean number of foetuses, mean foetal body weight and the sex ratio was similar to controls.

No external foetal anomalies were observed.

Ref.: 15

Main study

1 Guideline: OECD 414 (1981)
2 Species/strain: Sprague-Dawley rats Crl CD (SD) BR
3 Group size: 25 mated females
4 Test substance: Imexine BD suspended in water
5 Batch: OpT 54
6 Purity: 87.5 %
7 Dose: 0, 50, 200, 800 mg/kg bw by gavage
8 GLP: in compliance
9

10 The pregnant animals were treated daily by gavage from day 6 to 15 of gestation. Clinical
11 signs including mortality were twice a day checked. Food consumption was recorded from
12 days 2-6, 6-9, 12-15, and 15-20 of gestation. Body weights were recorded on days 2, 6, 9,
13 12, 15, and 20 of gestation. On day 20 the dams were sacrificed, the foetuses were
14 removed by Caesarean section and the number of implantations was determined. The
15 foetuses were weighed, checked for external abnormalities and sexed. Half of the foetuses
16 were submitted to soft tissue examination, one half to skeletal examination.
17

18 Results

19 No mortality and no clinical signs with the exception of Ptyalism and some discolouration at
20 800 mg/kg bw/d were observed. No changes in food consumption and body weight gain
21 were noted.

22 The resorption rate, mean number of foetuses, mean foetal body weight and the sex ratio
23 was similar to controls. No external foetal anomalies were observed. No substance-related
24 soft tissue anomalies were found. No treatment-related changes in the frequency of
25 variations and abnormalities were registered.

26 The NOAEL for maternal and foetotoxicity as well as teratogenicity was found to be 800
27 mg/kg bw/d.

28 Ref.: 16
29

30 **3.3.9. Toxicokinetics**

31
32 No data submitted
33

34 **3.3.10. Photo-induced toxicity**

35 3.3.10.1. Phototoxicity / photoirritation and photosensitisation

36
37 No data submitted
38

39 3.3.10.2. Phototoxicity / photomutagenicity / photoclastogenicity

40
41 No data submitted
42

44 **3.3.11. Human data**

45
46 No data submitted
47

48 **3.3.12. Special investigations**

49
50 No data submitted
51

1 **3.3.13. Safety evaluation (including calculation of the MoS)**

2 **CALCULATION OF THE MARGIN OF SAFETY**

3 **hydroxyanthraquinone-aminopropyl methyl morpholinium methosulfate**

Absorption through the skin	A	=	1.51 µg/cm²
Skin Area surface	SAS	=	580 cm²
Dermal absorption per treatment	SAS x A x 0.001	=	0.0.876 mg
Typical body weight of human		=	60 kg
Systemic exposure dose	SAS x A x 0.001/60	=	0.015 mg/kg bw/d
No Observed Adverse Effect Level (13-week, oral route, rat)	NOAEL	=	50 mg/kg bw/d
Bioavailability 50%		=	100

MOS	=	1667
------------	---	-------------

20 **3.3.14. Discussion**

21 *Physico-Chemical Properties*

22 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate is used in direct hair
23 dye formulations at a maximum concentration of 0.5%.
24 Purity: 87.5%. Impurities include 1.2% 1-Hydroxy-4-(3-morpholin-4-yl-propylamino)-
25 anthracene-9,10 dione, three other impurities with proposed tentative structures water and
26 residual solvents. Hydroxyanthraquinone-aminopropyl methyl morpholinium methosulfate is
27 a secondary amine, and thus, it is prone to nitrosation. ATNC (Apparent Total Nitroso
28 Content expressed as N-nitroso (NNO)) content in 3 of the 4 batches was 120-360 ppb
29 NNO, indicating that nitrosamine content in Hydroxyanthraquinone aminopropyl methyl
30 morpholinium methosulfate may be over 50 ppb. The nitrosamine content must be below 50
31 ppb, and the hairdye should not be used together with nitrosating agents in a hairdye
32 formulation. Solubility of Hydroxyanthraquinone-aminopropyl methyl morpholinium
33 methosulfate has not been determined by EU Method A.6. The Log Pow strongly depends on
34 the pH, especially for ionisable molecules, zwitterions etc. Therefore, a single calculated
35 value of Log Pow, usually without any reference to the respective pH, cannot be correlated
36 to physiological conditions and to the pH conditions of the percutaneous absorption studies.
37 Stability of Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate in typical
38 hair dye formulations has not been reported.

39 *General Toxicity*

40 The acute oral toxicity of Hydroxyanthraquinone aminopropyl methyl morpholinium
41 methosulfate (87.5% pure) in both sexes of rats was estimated to be < 2000 mg/kg. The
42 NOAEL was 50 mg/kg bw/d in a 13 week sub-chronic oral toxicity study in rats. The NOAEL
43 for maternal, foetal toxicity and teratogenicity in rats was 800 mg/kg bw/d.

44 *Irritation/Sensitisation*

45 Because of staining of the skin, evaluation of irritant potential has not been possible.
46 However, it was not an irritant to the rabbit eye.

47 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate is a strong contact
48 allergen.

49 *Percutaneous absorption*

50 Percutaneous absorption of Hydroxyanthraquinone aminopropyl methyl morpholinium
51 methosulfate, present in a hair dye formulation, has been determined to be 0.89 ± 0.31

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

1 µg/cm² in human dermatomed abdominal skin. As this study was non-guideline, the amount
2 considered absorbed for calculating the MOS is mean + 2SD. This is 1.52% of the applied
3 does or 1.51 µg/cm².

4 *5 Mutagenicity/Genotoxicity*

5 Overall, the genotoxicity of hydroxyanthraquinone aminopropyl methyl morpholinium
6 methosulfate is sufficiently investigated in valid genotoxicity tests for the 3 endpoints of
7 genotoxicity: gene mutations, chromosome aberrations and aneuploidy.

8 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate induced gene
9 mutations both in two gene mutation tests in bacteria and in a mouse lymphoma assay at
10 the *tk* locus. In the latter test, next to large colonies, also the number of small colonies
11 increased which may indicate to a clastogenic next to a mutagenic effect of. Two *in vitro*
12 chromosome aberration tests were positive confirming the clastogenic potential found in the
13 mouse lymphoma assay. A gene mutation test in mammalian cells using the *hprt* locus was
14 negative.

15 The positive findings from the *in vitro* tests for both gene mutations and chromosome
16 aberrations were not confirmed in *in vivo* tests. An *in vivo* micronucleus test in mice and
17 two unscheduled DNA synthesis tests were negative.

18 Consequently, on the basis of these tests, hydroxyanthraquinone aminopropyl methyl
19 morpholinium methosulfate can be considered to have no genotoxic potential and additional
20 tests are unnecessary.

21

22 **4. CONCLUSION**

23 The SCCS is of the opinion that the use of Hydroxyanthraquinone aminopropyl methyl
24 morpholinium methosulfate with a maximum concentration of 0.5% in non-oxidative hair
25 dye formulations does not pose a risk to the health of the consumer, apart from its
26 sensitising potential.

27 Hydroxyanthraquinone aminopropyl methyl morpholinium methosulfate is a secondary
28 amine, and thus it is prone to nitrosation. It should not be used together with nitrosating
29 agents. The nitrosamine content should be <50 ppb.

30 This hair dye is a strong skin sensitisier.

31

32 **5. MINORITY OPINION**

33

34 **6. REFERENCES**

35 *Submission I, 2003*

- 36
- 37 1. S. de Jouffrey. Acute Oral Toxicity in Rats. CIT Study No. 12382 TAR (94/2/090), May
38 5, 1995
 - 39 2. S. de Jouffrey. Acute Eye Irritation in Rabbits. CIT Study No. 12384 TAL (94/2/088),
40 March 29, 1995
 - 41 3. S. de Jouffrey. Acute Skin Irritation in Rabbits. CIT Study No. 12383 TAL (94/2/089),
42 March 13, 1995
 - 43 4. S. de Jouffrey. Skin Sensitization Test in Guinea Pigs. (Maximization method of
44 Magnusson, B. and Kligman, A.M.). CIT Study No. 12385 TSG (94/2/087), May 5,
45 1995
 - 46 5. S. de Jouffrey. Skin Sensitization Test in Guinea Pigs. Buehler Test (3 applications).
47 CIT Study No. 12700 TSG (95/2/001), July 11, 1995
 - 48 6. G. Arcelin. Contact Hypersensitivity in Albino Guinea Pigs – Bühler Test.RCC Study No.
49 732971, September 6, 1999

Opinion on Hydroxyanthraquinone-aminopropyl Methyl Morpholinium Methosulfate

- 1 7. G. Arcelin. Contact Hypersensitivity in Albino Guinea Pigs – Bühler Test. RCC Study
2 No. 745053, November 8, 1999
3 8. C. Fabreguettes. Preliminary 2-Week Toxicity Study by Oral Route in Rats. CIT Study
4 No. 12416 TSR (CIAUL 94/2/105), March 14, 1995
5 9. C. Fabreguettes. 13-Week Toxicity Study by Oral Route in Rats. CIT Study No. 12417
6 TCR (95/2/002), November 6, 1995
7 10. B. Molinier. Reverse Mutation Assay on Bacteria *Salmonella typhimurium* and
8 *Escherichia coli*. CIT Study No. 12409 MMO (95/2/092), June 21, 1995
9 11. B. Molinier. *In Vitro* Mammalian Cytogenetic Test in CHO Chinese Hamster Ovary Cells.
10 CIT Study No. 12410 MIC (94/2/091), July 5, 1995
11 12. B. Molinier. *In Vitro* Mammalian Cell Gene Mutation Test in L5178Y TK +/- Mouse
12 Lymphoma Cells. CIT Study No. 12720 MLY (95/2/020), January 17, 1996
13 13. S. de Jouffrey. Bone Marrow Micronucleus Test by Oral Route in Mice. CIT Study No.
14 13520 MAS (95/2/069), July 3, 1996
15 14. W. Völkner. *In Vivo / In Vitro* Unscheduled DNA Synthesis in Rat Hepatocytes with
16 Imexine BD. CCR Study No. 587901, October 21, 1997
17 15. M.H. Savary. Preliminary Embryotoxicity/Teratogenicity Study by Oral Route (Gavage)
18 in Rats. CIT Study No. 12375 RSR (94/2/107), March 2, 1995
19 16. C. Fabreguettes. Embryotoxicity/Teratogenicity Study by Oral Route (Gavage) in Rats.
20 CIT Study No. 12509 RSR (94/2/108), November 23, 1995
21 17. F. Hueber. *In Vitro* Percutaneous Absorption of Imexine BD (Colipa C177). L'Oréal
22 Unité de Biodisponibilité Cutanée, Study No. 16047, March 3, 2000
23
24

25 *Submission II, 2005*

- 26
27 1. Hydroxyanthraquinone-aminopropyl methyl morpholinium methosulfate. COLIPA n°
28 C117. Response to the comments of the SCCP: SCCP/0875/05. Analytical dossier.
29 JULY 2005
30 2. M. Johnson. Bacterial Reverse Mutation Test in Five Histidine-requiring Strains of
31 *Salmonelia typhimurium*. Covance Laboratories Ltd Study No.413/61, 2004.
32 3. M. Lloyd. Mutation at the hprt Locus of L5178Y Mouse Lymphoma Cells Using the
33 Microtit^eRFluctuation Technique. Covance Laboratories Ltd Study No.413/62, 2004.
34 4. M. Lloyd. Induction of Chromosome Aberrations in Cultured Human Peripheral Blood
35 Lymphocytes. Covance Laboratories Ltd Study No.413/63, 2004
36