2 Drugs Containing Anthracene Derivatives

The characteristic constituents of this drug group are anthraquinones, oxanthrones, anthranols and anthrones with laxative properties. The anthraquinones possess phenolic groups on C-1 and C-8 and keto groups on C-9 and C-10. In the anthrones and anthranols, only C-9 carries an oxygen function. In addition, a methyl, oxymethyl or carboxyl group may be present on C-3, and a hydroxy or methoxy group on C-6. Most compounds in this group are present in the plant as O-glycosides. The glycoside linkage is usually at C-1, C-8 or C-6-OH. C-Glycosides occur as anthrones only, with the C–C bond always at C-10. In the O- and C-glycosides, the only sugars found so far are glucose, rhamnose and apiose.

2.1 Preparation of Extracts

Powdered drug (0.5 g) is extracted for 5 min on a water bath with 5 ml methanol. The filtrate is used for TLC: 5 µl (Aloe) and 20 µl (Rheum, Frangula, Cascara).

Sennae folium or fructus are extracted with 50% methanol; 20 µl is used for TLC.

Powdered drug (0.5 g) and 25 ml 7.5% hydrochloric acid are heated under reflux for 15 min. After cooling, the mixture is extracted by shaking with 20 ml ether. The ether phase is concentrated to about 1 ml, and 10 µl is used for TLC (e.g. Rhei radix).

2.2 Thin-Layer Chromatography

Aloin, frangulin A/B, glucofrangulin A/B, rhein, aloe-emodin and rhaponticoside (stilbene glucoside) are applied as 0.1% methanolic solutions.

Sennosides A and B are prepared as a 0.1% solution in methanol-water (1:1). A total of 10 µl of each reference solution is used for TLC.

Chromatography is performed on silica gel 60F254 precoated plates (Merck, Germany).

- Ethyl acetate-methanol-water (100:13.5:10)
  With the exception of Senna preparations, the solvent system is suitable for the chromatography of all anthracene drug extracts.
- n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1) ▶ Senna
- light petroleum-ethyl acetate-formic acid (75:25:1) ▶ anthraquinone aglycones
• toluene-ethyl formiate-formic acid (50:40:10) or (50:20:10) for the non-laxative dehydrodianthrones of Hyperici herba

2.3 Detection

• UV 254 nm All anthracene derivatives quench fluorescence
• UV 365 nm All anthracene derivatives give yellow or red-brown fluorescence

• Spray reagents (See Appendix A)
  – Potassium hydroxide (KOH No. 35; → Bornträger reaction)
    After spraying with 5% or 10% ethanolic KOH, anthraquinones appear red in the visible and show red fluorescence in UV-365 nm.
    Anthrones and anthranols: yellow (vis.), bright yellow fluorescence (UV-365 nm).
    Dianthrones do not react.
  – Natural products-polyethylene glycol reagent (NP/PEG No.28)
    Anthrones and anthranols: intense yellow fluorescence (UV-365 nm).
  – Sennoside detection
    The TLC plate is sprayed with concentrated HNO₃ and then heated for 10 min at 120°C. It is then sprayed with 5% ethanolic KOH. After further heating, sennosides appear as brown-red zones in UV-365 nm and brown zones in the visible.
    Sennosides can also be detected with a 1% solution of sodium metaperiodate in 10% ethanolic KOH. After spraying and heating (approximately 5 min), yellow-brown zones are obtained in UV-365 nm.
  – Rhaponticoside detection
    Phosphomolybdate-\(\text{H}_2\text{SO}_4\) reagent (PMA-\(\text{H}_2\text{SO}_4\) No.36)
    Rhaponticoside gives dark blue zones in the visible
  – Hypericin detection
    A 10% solution of pyridine in acetone intensifies the red fluorescence of hypericin in UV-365 nm.
  – “Isobarbaloin” test for the differentiation of Aloe capensis and Aloe barbadensis.
    One drop of saturated \(\text{CuSO}_4\) solution, 1 g NaCl and 10 ml 90% ethanol are added to 20 ml of an aqueous solution of Aloe barbadensis (Curacao aloe, 1:200). A wine-red colour is produced, which is stable for at least 12 h. Solutions of Aloe capensis fade rapidly to yellow.
2.4 Circular TLC in Addition to the Ascending TLC

This method is generally useful for the separation of drug extracts containing a high proportion of ballast substances, e.g. mucilages from Sennae folium.

Two diagonal pencil lines are drawn from the corners of the TLC plate. The centre point of the plate is marked and a circle is drawn around it with a diameter of approximately 2 cm. The circle is thus divided into four segments by the diagonals. The perimeter of each segment serves for the application of drug extracts or reference solutions (see figure below).

Procedure

100 ml of solvent are placed in a round, straight-sided chamber (glass trough, 10 cm high, 20 cm in diameter). A glass funnel is loosely packed with cotton, which extends as a wick through the tube of the funnel. The funnel is placed in the solvent system, so that the solvent soaks into the cotton. With the loaded side facing downwards, the TLC plate is placed over the top of the trough, so that the cotton makes contact exactly at the marked centre.

The solvent migrates circularly from the point of application. The zones of the separating substances form single arcs, which increase in length from the starting point to the periphery of the spreading solvent.

The same adsorbent (silica gel 60 F_{254} precoated plates, 20 × 20 cm; Merck, Darmstadt), the solvent systems and detection methods can be used as described for ascending TLC. Good separations are obtained by solvent migrations of 6 cm only.
### 2.5 Drug List

<table>
<thead>
<tr>
<th>Drug/plant source</th>
<th>Main constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family/pharmacopoeia</td>
<td>Hydroxyanthracenes</td>
</tr>
</tbody>
</table>

**Fig. 1,2 Aloe**
- Various types such as: Cape and Curacao aloes, Socotrine aloes
- DAB 10, Helv VII, USP XXII, MD
- Uganda, Kenya aloe, Indian aloe
- Asphodelaceae (Liliaceae)

Dried juice of aloe leaves.
Aloin A, B (10-C-\(\beta\)-D glucopyranoside of aloe emodin-anthrone), \(\alpha\)- and \(\beta\)-stereoisomers
Aloinoside A and B (stereoisomers of aloin-11-\(\alpha\)-L-rhamnoside), aloe-emodin (aglycone)
Aloeresins (non-laxative compounds):
  - aloesin A (chromone-C-glucoside),
  - aloesin B (p-coumaric acid ester of aloesin A),
  - aloesin C (glucoside of aloesin B)

**Fig. 1,2 Aloe capensis**
- Cape aloe
- Aloe ferox MILLER and hybrids
- DAB 10, BHP 90, ÖAB 90, USP XXII, Helv VII, Jap XI

Not less than 18% hydroxyanthracenes calculated as aloin (e.g. DAB 10)
Aloin A/B, aloesins A/B (type I)
Aloin A/B, aloinosides A/B, aloesin A/B (type II), 5-hydroxyaloin A/B, aloe-emodin (<1%)

**Fig. 1,2 Aloe barbadensis**
- Curacao aloe, Aloe vera
- Aloe barbadensis MILL.
- DAB 10, BHP 90, Helv VII, ÖAB 90, USP XXII, MD

Not less than 28% hydroxyanthracenes calculated as aloin (DAB 10)
Aloin A/B, 7-hydroxyaloin A/B (3%)
8-Methyl-7-hydroxyaloin A/B, aloesin B/D

**Fig. 2 Aloe perry**
- Socotrine aloes
- Aloe perryi BAK.
- MC

Up to 14% hydroxyanthracene derivatives calculated as aloin
Aloin A/B, aloinosides A/B, aloesins A/B

**Fig. 4 Rhamni purshianensis cortex**
- Casuariae sagradae cortex
- Cascara sagrada bark
- Sacred bark, chitten bark
- Rhamnus purshianus D.C.
- Rhamnaceae
- DAB 10, PhEur II, ÖAB 90, Helv VII, MD
- USP XXII (extract)

Not less than 8% hydroxyanthracenes with at least 60% cascarosides calc. as cascaroside A (DAB 10)
Cascarosides A and B (diastereoisomers of aloin-8-O-\(\beta\)-D-glucoside); cascarosides C and D (diastereoisomers of deoxyaloin-8-O-\(\beta\)-D-glucoside); Aloin, deoxyaloin (10%–20%), small amounts of emodine; frangula-emodin-O-glucosides (10%–20%)

**Fig. 3 Frangulae cortex**
- Rhamni frangulae cortex
- Alder buckthorn bark
- Rhamnus frangula L.
- Rhamnaceae
- DAB 10, PhEur II, Helv VII, MD

Not less than 6% anthraquinone glycosides
Glucofrangulin A and B (emodin-6-O-\(\alpha\)-L-rhamnosyl-8-O-\(\beta\)-D-glucoside and -6-O-\(\alpha\)-L- apiosyl-8-O-\(\beta\)-D-glucoside). Frangulin A and B (emodin-6-O-\(\alpha\)-L-rhamnoside and emodin-6-O-\(\alpha\)-L-apioside).
Emodin-8-\(\beta\)-O-glucoside, -diglucoside
Physcion, chrysophanol glycosides
<table>
<thead>
<tr>
<th>Drug/plant source</th>
<th>Main constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frangulae fructus</strong></td>
<td>Low concentrations of anthraquinone aglycones and traces of anthraquinone glycosides.</td>
</tr>
<tr>
<td>Alder buckthorn fruits</td>
<td></td>
</tr>
<tr>
<td>Rhamnus frangula L.</td>
<td></td>
</tr>
<tr>
<td>Rhamnaceae ÖAB</td>
<td></td>
</tr>
<tr>
<td><strong>Oreoherzogiae cortex</strong></td>
<td>1%–3% Hydroxyanthracene derivatives</td>
</tr>
<tr>
<td>Rhamni fallaci cortex</td>
<td>Emodin-glucoside, physcion-rutinoside</td>
</tr>
<tr>
<td>Rhamnus alpinus L. ssp.</td>
<td>Flavonoids: e.g. xanthorhamnin</td>
</tr>
<tr>
<td>fallax (BOISS.) PETITMAIRE</td>
<td>► adulterant of Frangulae cortex</td>
</tr>
<tr>
<td><strong>Rhamni cathartici fructus</strong></td>
<td></td>
</tr>
<tr>
<td>Buckthorn berries</td>
<td>Low contents of anthraquinones in fruit flesh,</td>
</tr>
<tr>
<td>Rhamnus catharticus L.</td>
<td>0.7%–1.4% hydroxyanthracenes in semen:</td>
</tr>
<tr>
<td>MD</td>
<td>frangulaemodin, -emodinanthrone</td>
</tr>
<tr>
<td></td>
<td>Flavonol glycosides &gt;1%: xanthorhamnines</td>
</tr>
<tr>
<td></td>
<td>= triglycosides of rhamnocitrin (7-methyl-kaempferol and 7-methyl-quercetin)</td>
</tr>
<tr>
<td></td>
<td>Catharticin (rhamnocitrin-3-O-β-rhamnoside)</td>
</tr>
<tr>
<td><strong>Rhei radix</strong></td>
<td>1%–6% Hydroxyanthracenes (not less than 2.5%);</td>
</tr>
<tr>
<td>Rhubarb rhizome</td>
<td>60%–80% of mono- and diglycosides of</td>
</tr>
<tr>
<td>Rheum officinale BAILLON</td>
<td>physcion, chrysophanol and rhein (e.g.</td>
</tr>
<tr>
<td>Rheum palmatum L. and hybrids</td>
<td>physcion-8-O-gentiobioside); rhein, physcion,</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>chrysophanol, emodin, aloe-emodin;</td>
</tr>
<tr>
<td>DAB 10, ÖAB. MD, Japan,</td>
<td>bianthronglycosides: rheidin A-C, sennidin</td>
</tr>
<tr>
<td>China</td>
<td>C,D, galloyl-β-D-glucose</td>
</tr>
<tr>
<td><strong>Rhei rhapontici radix</strong></td>
<td>0.3%–0.5% anthraquinone aglycones and glucosides, 7%–10% stilbene derivatives:</td>
</tr>
<tr>
<td>Garden rhubarb</td>
<td>rhaponticoid 5%, desoxyrhaponticoid,</td>
</tr>
<tr>
<td>Rheum rhaponticum L.</td>
<td>Adultrant of Rhei radix</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td></td>
</tr>
<tr>
<td><strong>Sennae folium</strong></td>
<td>2%–3.5% dianthrone glycosides (not less than 2.5%), calc. as sennoside B for</td>
</tr>
<tr>
<td>Senna leaves</td>
<td>Alexandrian and Tinevelly senna (e.g. DAB 10). As principal active compounds:</td>
</tr>
<tr>
<td>Cassia senna L.</td>
<td>sennoside A and B as 8,8’-diglycosides of</td>
</tr>
<tr>
<td>(Alexandrian senna)</td>
<td>sennidin A/B (= stereoisomeric 10-10’-dimers of rhein anthrone)</td>
</tr>
<tr>
<td>Cassia angustifolia VAHL</td>
<td>Sennoside A (dextrorotatory), sennoside A, (optical isomer), sennoside B (optically</td>
</tr>
<tr>
<td>(Tinevelly senna)</td>
<td>inactive mesoform)</td>
</tr>
<tr>
<td>Caesalpiniaeae</td>
<td>low amounts of Sennoside C and D (=heterodianthrones), rhein, emodin and</td>
</tr>
<tr>
<td>DAB 10, ÖAB 90, Helv VII,</td>
<td>their mono- and diglycosides</td>
</tr>
<tr>
<td>Jap XI, MD</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3,4
Fig. 3
Fig. 3,4
Fig. 5,6
Fig. 7,8
2.6 Formulae
<table>
<thead>
<tr>
<th>Compound</th>
<th>R&lt;sub&gt;1&lt;/sub&gt;</th>
<th>R&lt;sub&gt;2&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucofrangulin A</td>
<td>α-L-rhamnose</td>
<td>β-D-glucose</td>
</tr>
<tr>
<td>Glucofrangulin B</td>
<td>β-D-apiose</td>
<td>β-D-glucose</td>
</tr>
<tr>
<td>Frangulin A</td>
<td>α-L-rhamnose</td>
<td>H</td>
</tr>
<tr>
<td>Frangulin B</td>
<td>β-D-apiose</td>
<td>H</td>
</tr>
<tr>
<td>Frangula emodin</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Rheum emodin</td>
<td>CH&lt;sub&gt;3&lt;/sub&gt;</td>
<td>OH</td>
</tr>
<tr>
<td>Aloe emodin</td>
<td>CH&lt;sub&gt;2&lt;/sub&gt;OH</td>
<td>H</td>
</tr>
<tr>
<td>Rhein</td>
<td>COOH</td>
<td>H</td>
</tr>
<tr>
<td>Chrysophanol</td>
<td>CH&lt;sub&gt;3&lt;/sub&gt;</td>
<td>H</td>
</tr>
<tr>
<td>Physcion</td>
<td>CH&lt;sub&gt;3&lt;/sub&gt;</td>
<td>OCH&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Rhaponticoside: R = β-D-glucose
Rhapontigenin: R = H

Sennoside A: R<sub>1</sub>, R<sub>1</sub> = COOH (+)-form
Sennoside B: R, R<sub>1</sub> = COOH mesoform

Sennoside C: R = COOH R<sub>1</sub> = CH<sub>3</sub>OH (+) form
Sennoside D: R = COOH R<sub>1</sub> = CH<sub>2</sub>OH mesoform
Protohypericin
$R_1 = R_2 = \text{CH}_3$
Protopseudohypericin
$R_1 = \text{CH}_3 \quad R_2 = \text{CH}_2\text{OH}$

4-4’: Hypericin
$R_1 = R_2 = \text{CH}_3$
4-4’: Pseudohypericin
$R_1 = \text{CH}_3 \quad R_2 = \text{CH}_2\text{OH}$
2.7 Chromatograms

Aloes

<table>
<thead>
<tr>
<th>Drug sample</th>
<th>Aloe capensis (type I)</th>
<th>4 Aloe perryi (Socotrine aloe)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Aloe capensis (type II)</td>
<td>5 Aloe of Kenian origin</td>
</tr>
<tr>
<td></td>
<td>3 Aloe barbadensis (Curacao aloe)</td>
<td>6 Aloe of Ugandan origin</td>
</tr>
<tr>
<td>(methanolic extracts, 5μl)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reference Compound

| T1 | aloin |
|    | aloin (Rf ~ 0.45) → aloin |
| T2 | 7-hydroxyaloin |
|    | emodin (Rf ~ 0.95) |

Solvent system

ethyl acetate-methanol-water (100:13.5:10)

Detection

Fig. 1 Without chemical treatment → A UV-365 nm, B UV-254 nm
Fig. 2 10% ethanolic KOH reagent (No. 35) → C UV-365 nm, D vis

Aloe species are characterized by aloin A/B, aloe-emodin and the non-laxative aloeresins (aloesin A–C). In addition some aloe contain aloinosides and substituted aloins (5- or 7-hydroxyaloin A/B).

Fig. 1 Aloe capensis (1,2)

A Cape Aloe (1) is characterized by the yellow fluorescent zone of aloin (Rf ~ 0.5/T2) and aloe-emodin (solvent front). The zones of aloeresins such as aloesin A and B (Rf ~ 0.55 and Rf ~ 0.25, respectively) fluoresce light blue.

Trade samples of Cape aloe (2) can show besides the yellow fluorescent aloin and aloe-emodin, additional yellow zones of the aloinosides A/B (Rf 0.25–0.3) and additional glycosides (e.g. Rf ~ 0.75). The blue fluorescent zones are less prominent than in sample 1 (e.g. aloe resins).

B All major compounds, such as aloins or aloinosides and specifically the aloesins show quenching in UV-254 nm.

Note: 7-hydroxyaloin (T2) a characteristic compound in Curacao aloes (3) is absent in Cape aloes (1,2).

Fig. 2 TLC synopsis of aloes (1–6)

C Treatment with KOH reagent intensifies the yellow fluorescence of aloin and aloinosides as well as the blue fluorescence of the aloe resins. Aloe-emodin shows a typical red Bornträger reaction in UV-365 nm.

<table>
<thead>
<tr>
<th>Aloe resins</th>
<th>Aloin</th>
<th>Aloinosides</th>
<th>Aloesins</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cape aloe</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>Cape and Curacao aloes are differentiated</td>
</tr>
<tr>
<td>2 Cape aloe</td>
<td>+</td>
<td>−−</td>
<td>++</td>
<td>by the &quot;isobarbaloin-test&quot; of Klunge</td>
</tr>
<tr>
<td>3 Curacao aloes</td>
<td>++</td>
<td>−−</td>
<td>++</td>
<td>(see section 2.3) which gives yellow or</td>
</tr>
<tr>
<td>4 Socotrine aloes</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>wine red colour, respectively</td>
</tr>
<tr>
<td>5 Kenya aloes</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
<td>Socotrine and Curacao aloes show a dark</td>
</tr>
<tr>
<td>6 Uganda aloes</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>zone directly below aloin, e.g.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7-hydroxyaloin in 3</td>
</tr>
</tbody>
</table>

D All Aloe (1–4) samples show aloin as prominent yellow zones (vis.). The samples 2 and 4 contain, in addition, aloinosides (yellow Rf 0.25–0.3), and a dark violet-red zone (vis.) characterizes Curacao (3) and Socotrine aloe (4). This zone directly below aloin can be identified in (3) as 7-hydroxyaloin.
**Rhamnus species**

**Drug sample**
1. Frangulae cortex (Rhamnus frangula)
2. Oreohertzogiae cortex (Rhamnus alpinus ssp. fallax)
3. Frangulae fructus (Rhamnus frangula)
4. Rhamni carthartici fructus (Rhamnus cartharticus)
5–7. Cascareae cortex (Rhamnus purshianus-trade samples) (methanolic extracts, 20 μl)

**Reference compound**
- T1: glucofrangulin A (Rf 0.25) ▶ aloin (Rf 0.45) ▶ frangulin A (Rf 0.75) ▶ emodin (front)
- T2: aloin

**Solvent system**
ethyl acetate-methanol-water (100:13.5:10)

**Detection**
- Fig. 3 KOH reagent (No. 35) A → vis; B, C → UV-365 nm
- Fig. 4 Natural products-polyethylene glycol reag. (NP/PEG No. 28) D, E → UV-365 nm

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**Fig. 3** Anthraquinones

A. **Frangulae cortex** (1) is characterized by two pairs of red-brown anthraquinone glycosides (vis.): glucofrangulin A (Rf 0.2), B (Rf 0.3) and frangulin A (Rf 0.75), B (Rf 0.8). Aglycones such as emodin, physcion and chrysophanol move with the solvent front.

**Oreohertzogiae cortex** (2) counts as an adulterant of Frangulae cortex: glucofrangulin A/B present in considerably lower concentration, only traces of frangulin A/B, additional anthraquinone glycosides such as physcion-rutinoside (Rf ~ 0.3) and emodin-glucoside (Rf ~ 0.5) dominate. A yellow zone at Rf ~ 0.2 in both samples (1,2) is due to flavonol glycosides see Fig. 4 D.

B. All anthraquinones of Frangulae and Oreohertzogiae cortex (1,2) show a bright orange-red fluorescence in UV-365 nm.

C. **Frangulae fructus** (3) shows only traces of frangula-epomadin at the solvent front.

**Rhamni carthartici fructus** (4). Four to five orange-red zones are detectable in the Rf range of glucofrangulin (Rf ~ 0.25), frangulin (Rf ~ 0.8) and above.

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**Fig 4** Flavonoids and cascarosides

D. **Frangulae cortex** (1): one green fluorescent flavonoid glycoside (Rf ~ 0.2) and the zones of frangulin A/B with brown fluorescence.

**Frangulae fructus** (3): two yellow orange fluorescent flavonol glycosides (Rf 0.15/0.45).

**Rhamni cathartici fructus** (4): a band of prominent orange-yellow fluorescent xanthorhammins (triglycosides, see 2.5 Drug List) between the start and Rf ~ 0.25, and between Rf ~ 0.75 up to the solvent front. Xanthorhammin (Rf ~ 0.2) is found in (3) and (4).

E. **Cascareae cortex** (5–7) samples are characterized by anthrone glycosides: two pairs of yellow fluorescent cascarosides A/B (Rf 0.05–0.15) and cascarosides C/D (Rf 0.2–0.25). The cascarosides A/B dominate. The amount of yellow fluorescent aloin (T2), deoxyaloin (Rf 0.65) and the red-brown fluorescent aglycones emodin, aloe-epomadin, chrysophanol (solvent front) varies. Four blue fluorescent naphthalide derivatives are detectable in the Rf range 0.3–0.45.

*Note:* Cascarosides A–C also fluoresce bright yellow when treated with the KOH reagent.
Rhei radix

Drug sample
1 Rhei palmati radix (methanolic extract, 20 μl)
2 Rhei rhapontici radix (methanolic extract, 20 μl)
3 Rhei palmati radix (hydrolysate, 10 μl)
4 Rhei rhapontici radix (hydrolysate, 10 μl)

Reference compound
T1 rhei
T2 rhaponticoside
T3 emodin (Rf ~ 0.4)

Solvent system
Fig. 5 ethyl acetate-methanol-water (100:13.5:10) → glycosides
Fig. 6 light petroleum-ethyl acetate-formic acid (75:25:1) → aglycones

Detection
A Without chemical treatment → UV-365 nm
B Phosphomolybdic acid/H₂SO₄ reagent (PMS No. 34) → vis
C Without chemical treatment → UV-254 nm
D Without chemical treatment → UV 365 nm

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Fig. 5 Glycosides

A Rhei radix (1) is characterized in UV-365 nm by the prominent yellow fluorescent authraquinone aglycone zone (emodin, aloe-emodin, physcion, chrysophanol) at the solvent front. Their 8-O-monoglucosides migrate as a brown-red band to Rf 0.45–0.55. The corresponding diglycosides are present as minor compounds in the Rf range 0.1–0.3. The polar aglycone rhei (T1) at Rf ~ 0.4 is overlapped by blue fluorescent zones.

Rhei rhapontici radix (2) contains authraquinone aglycones and monoglucosides in low concentration only. In addition the prominent violet-blue fluorescent stilbene derivatives rhaponticoside/deoxyrhaponticoside (Rf 0.45–0.55/T2) are present. They overlap the authraquinone monoglucoside zone.

B Treatment with the PMA reagent produces light yellow zones of authraquinones (1) and a characteristic dark blue band of rhaponticoside/deoxyrhaponticoside (T2) and rhapontigenin (solvent front) in sample 2.

Fig. 6 Aglycones

C,D The aglycone mixtures (3,4) obtained by HCl hydrolysis of Rheum extracts (1,2) are separated in the lipophilic solvent system and evaluated in UV-254 nm and UV-365 nm. All aglycones show fluorescence quenching in UV-254 nm and uniformly yellow or orange-brown fluorescence in UV-365 nm.

Rhei palmati radix (3). Aloe-emodin and rhei (Rf 0.15–0.25/T1), emodin (Rf ~ 0.3/T3), chrysophanol and physcion (Rf 0.6–0.7) are characteristic aglycones.

Rhei rhapontici radix (4). The hydrolysate shows a qualitatively similar, but quantitatively different aglycone pattern with traces of rhei (T1) only. In addition blue fluorescent stilbene aglycones are found at Rf 0.05–0.1.
Fig. 5

Fig. 6
**Sennae folium, fructus**

**Drug sample**
1. Sennae fructus (methanolic extract, 20μl)
2. Sennae folium (methanolic extract, 20μl)

**Reference compound**
T1 sennoside A°
T2 sennoside B°

**Solvent system**
n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1)

**Detection**

- Fig. 7  HNO₃-potassium hydroxide reagent (HNO₃/KOH No.30) → vis
- Fig. 8 A  HNO₃-potassium hydroxide reagent (HNO₃/KOH No.30) → UV-365 nm
  
  **B** Sodium metaperiodate reagent (see 2.3 Detection) → UV-365 nm

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**Fig. 7** Sennae fructus (1) and folium (2)

Treatment of the TLC plate with concentrated HNO₃, heating for approximately 30 min at 150°C and spraying with KOH reagent produces six to eight brownish and yellow zones (vis) in the Rf range 0.1 up to the solvent front.

The dark-brown zones are due to the sennosides B,A (Rf 0.25 and Rf 0.4) and the sennosides D,C (Rf 0.5 and Rf 0.7). The yellow zones indicate anthraquinone aglycones (e.g. rhein/Rf ~ 0.8; emodine/solvent front) and their glucosides (Rf ~ 0.3/Rf ~ 0.6).

**Fig. 8A**

Evaluation under UV-365 nm light is more sensitive. The main brown zones (vis.) of Sennae extracts (1,2) now appear light brown to orange-brown. The minor compounds of the Rf range 0.5–0.9 are also more easily detectable.

The two dianthron glycosides, sennoside A (Rf 0.4/T1) and sennoside B (Rf 0.25/T2) are the major compounds in Sennae fructus (1) and S. folium (2).

In Sennae folium extract (2) a Rf value depression of sennoside A and specifically of sennoside B occur, caused by the mucilages also extracted from the plant material with 50% methanol. To avoid this effect the circular TLC method can be used (see Fig. 9).

Sennoside D (Rf ~ 0.55) is more highly concentrated in Sennae folium extracts (2) than in Sennae fructus extracts (1). Sennoside C can be localized at Rf ~ 0.7. Rhein is detectable as a yellow zone at Rf ~ 0.8 and its 8-O-glucoside is found between sennoside D and C.

**B** Direct treatment of the TLC plate with the sodium metaperiodate reagent and heating for 5 min under observation at 100°C reveals green-yellow or dark brownish zones when evaluated under UV-365 nm. It is a fast detection method, but less sensitive compared with the HNO₃/KOH reagent.

°The commercial reference compound “sennoside A” contains small amounts of sennoside C and D. The reference compound ”sennoside B” shows, in addition, sennoside A as minor component.
Circular TLC (CTLC) in comparison to ascending TLC of Senna extracts

**Drug sample, segment**
- Sennae folium (upper segment)  A sennoside A  D sennoside D
- Sennae fructus (lower segment) B sennoside B  Al aloin  Rh rhein

**Solvent system**
n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1)

**Detection**
- Fig. 9 CTLC Sodium metaperiodate reagent (see 2.3 Detection) \(\rightarrow\) vis
- Asc. TLC HNO\(_3\)-potassium hydroxide reagent (HNO\(_3\)/KOH No. 30) \(\rightarrow\) vis

**Description**
The CTLC in general is a convenient method to achieve good separations over the short distance of 5–6 cm. Extracts and reference compounds are applied in the inner circle (start) in an overlapping mode, to make sure that compounds are clearly identified by references. Ballast substances of the extracts such as mucilages are diluted in the circular separation lines. The disturbance and \(R_t\) value depression of sennoside A,B are reduced (preparation see 2.4 Circular TLC).

**Fig. 9**
The sennosides are detected as bright yellow-brown bands with sodium metaperiodate (CTLC) and as darker brown zones with the HNO\(_3\)-KOH reagent (asc. TLC). The CTLC of Sennae folium und Sennae fructus shows as two prominent circles sennoside A and B (\(\rightarrow\) test A/B) in the inner parts of both segments. The bands of sennoside D (\(\rightarrow\)D) and C are found slightly below the aloin test (\(\rightarrow\) test Al). Rhein (test \(Rh\)) is clearly seen in Sennae fructus extracts. The influence of mucilages on the \(R_t\) value of sennoside B results in a dwelling circle (CTLC) and causes an \(R_t\) value depression in the picture of the ascending TLC (compare with Figs. 7,8).

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**Hyperici herba**

**Drug sample**
1. Hyperici herba (Hypericum perforatum) (methanolic extracts, 25\(\mu\)l)
2. Hyperici herba (commercial trade sample)

**Reference compound**
- T1 hypericin
- T2 rutin (\(R_t\) 0.35) \(\triangleright\) chlorogenic acid (\(R_t\) 0.4) \(\triangleright\) hyperoside (\(R_t\) 0.5) \(\triangleright\) isochlorogenic acid

**Solvent system**
- Fig. 10 A,B ethyl acetate-formic acid-glacial acetic acid-water (100:11:11:26)
- C toluene-ethyl formate-formic acid (50:40:10)

**Detection**
- A,B Natural products-polyethylene glycol reagent (NP/PEG No. 28);
- A UV-365 nm, B vis.
- C 10% pyridine in ethanol \(\rightarrow\) vis

**Fig. 10A**

Hyperici herba (1,2) is characterized in UV-365 nm after treatment with NP/PEG reagent by the prominent red-violet fluorescent zones of the non-laxative dehydrodianthrons, the hypericins (\(R_t\) 0.75–0.8), five bright yellow fluorescent flavonolglycosides (\(R_t\) 0.35–0.7) and blue fluorescent phenol carboxylic acids such as chlorogenic acid (\(R_t\) 0.4/T2). The flavonolglycosides are identified as rutin (\(R_t\) 0.35/T2), hyperoside (\(R_t\) 0.5/T2), isoquercitrin (\(R_t\) 0.6) and quercitrin (\(R_t\) 0.7). The aglycones, e.g. quercetin, migrate with the red fluorescent chlorophylls to the solvent front.

- B Hypericins are seen as green-brown and the flavonolglycosides as orange-yellow zones (vis).
- C Variation of the solvent system and the detection with pyridine reagent reveals a broad band of red zones in the \(R_t\) range 0.5–0.6 (T1). Red zones at \(R_t\) 0.9–0.95 show chlorophyll compounds.
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