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PLANT GROWTH ACTIVITY OF EPOXIDES FROM DEHYDROCOSTUS LACTONE

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Key Word Index—*Saussurea lappa*; *Phaseolus aureus*; costus root oil; terpenoid lactones; plant growth regulators.

Terpenoid lactones in which the lactone carbonyl is conjugated with a methylenic double bond [1], a trisubstituted double bond [2] or a cyclopropane ring [2] have emerged in recent years as a group of new plant growth regulators. Cross-conjugated ketones [3] and related α,β-unsaturated terpenoid ketones [4] constitute other important groups of compounds which possess this activity.

Dehydrocostus lactone (**1**) [6] isolated from costus roots (*Saussurea lappa*) was reacted with 1 mol of perbenzoic acid. On chromatographic separation the resulting mixture afforded one monoepoxide, mp 82° and two isomeric diepoxides, mp 97° and 137°.

As expected all the three epoxides showed an intact α-methylene-γ-lactone moiety as revealed by IR bands at 1750, 1650 and 880–910 cm^{-1} and by displaying typical low field ^{1}H NMR signals for a conjugated methylenic double bond around δ 6.00 and 5.5, (1H each, mutually coupled doublets).

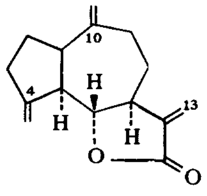
The compound with mp 82° showed another exo-methylene by displaying signals at δ 5.0 and 4.9 (1H each, *s*(*br*)). The C-6 proton appeared at 3.9 (*dd*, $J = 9$ and 10 Hz). The protons on the oxirane ring appeared as mutually coupled doublets at 3.27 and 2.73 ($J = 5$ Hz). Based on these spectral data and the known reactivity of perbenzoic acid, the epoxide ring should be present at C-4 or C-10. The enormous difference in chemical shift of the oxirane protons clearly ruled out C-10 as the possible site of the oxirane ring. It may be pointed out that the epoxide (**2**) shows its oxirane protons as a sharp two-proton singlet at δ 2.80 [7] consistent with the above conclusion. Based on these data two possible stereostructures (**3** and **4**) for the compound of mp 82° may be considered. Examination of models reveals that in the α-epoxide (**3**) the oxirane hydrogens are quite far removed from the lactone ring and hence should not have the observed difference in their chemical shift. In contrast, in the β-epoxide (**4**) one of the oxirane hydrogens is very close to the ether oxygen of the lactone and is, therefore, deshielded. Based on this consideration stereostructure (**4**) is preferred for this epoxide.

It is known [8] that allylic and homoallylic alcohols direct epoxide formation from the same side whereas in the corresponding acetates the opposite stereochemistry is observed. Our findings are, therefore, in agreement with this expectation.

The ^{1}H NMR and IR spectra of the compounds of mp 97° and 137° clearly revealed the presence of the C-4, β-epoxide and a second epoxy function in which the two new oxirane protons appeared around δ 2.8. These two compounds must, therefore, be epimeric epoxides (**5**) at C-10. A simple confirmation of this point involved the reaction of compound (**4**) with perbenzoic acid when products identical (TLC, IR and mmp) with the compound of mp 97° and 137° were obtained.

Biological activity

A recent review [5] records some of the structural features required for the biological activity of sesquiterpene lactones. These include antitumour, cytotoxic,



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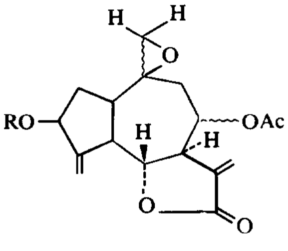

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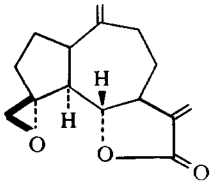

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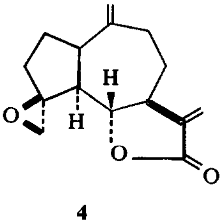

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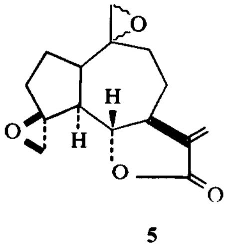

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Table 1. Effect of terpenoids on the root formation of *Phaseolus aureus*

Concentration (ppm)	5	10	20	40
Compound 1	9.4 ± 1.5	14.7 ± 1.6	24.7 ± 1.2	27.3 ± 1.3
Compound 4	12.1 ± 1.6	19.9 ± 1.3	38.4 ± 1.7	68.4 ± 1.2
Compound 5, mp 97°	13.2 ± 1.4	20.2 ± 1.6	37.6 ± 1.4	69.3 ± 1.6
Compound 5, mp 137°	13.0 ± 1.3	21.6 ± 1.2	30.4 ± 1.2	57.6 ± 1.4

The rooting tests were performed in the laboratory using the basic methodology of Hess [9]. Control experiments: H_2O, 10.9 ± 1.3; IAA (10 ppm) 21.2 ± 1.5.

antimicrobial and phytotoxic activity. These structural features include the presence of an exomethylene group conjugated to a γ-lactone. It is also reported that the presence of a functional group such as an epoxide, hydroxyl, chlorohydrin, unsaturated ketone or *O*-acyl adjacent to the α-methylene of the γ-lactone enhances the reactivity of the conjugated lactones towards biological nucleophiles thus increasing their biological action.

Our earlier success in establishing the relation between structure and plant growth activity prompted us to prepare various epoxides from dehydrocostus lactone (**1**) and to study the changes produced in root initiation by the added epoxy groups. Significantly we report that the root promoting action of dehydrocostus lactone, which has the intact and indispensable α-methylene-γ-lactone moiety for this action, was enhanced tremendously with the placement of an epoxide group at the C-4 position as in compound **4** (Table 1). No additional increase in this biological activity occurred due to a second epoxide at C-10 and the epimeric epoxide (**5**, mp 97° and 137°) individually showed comparable root promoting activity with **4**. The presence of an epoxide group adjacent to the α-methylene of the γ-lactone enhances the biological activity [5]. In compounds **4** and **5** reported in this paper the epoxide group is, however, present in a different structural environment.

EXPERIMENTAL

All the mps reported are uncorr. IR spectra were taken in nujol and ^1H NMR spectra were recorded on a 60 MHz apparatus using TMS as internal standard. CC was done on Si gel.

Dehydrocostus lactone (**1**) was isolated from costus root oil as described in ref. [6] and was identified by its superimposable IR spectrum with that of an authentic sample and by mmp determination.

Reaction of dehydrocostus lactone with perbenzoic acid. A soln of dehydrocostus lactone (5.75 g) in $CHCl_3$ (30 ml) was reacted with 1 mol of perbenzoic acid (60 ml 0.8 N perbenzoic acid in $CHCl_3$). After 24 hr at 9° the mixture was washed with aq. $NaHCO_3$, neutralized, dried (Na_2SO_4) and evapd to afford a mixture of products. This was chromatographed and elution of the column with petrol–Et_2O (9:1) afforded unreacted parent lactone. Elution with petrol–Et_2O (8:2) afforded **4**, mp 82°, as a pure compound. (Found: C, 73.25; H, 7.49. $C_{15}H_{18}O_3$ requires: C, 73.14; H, 8.68 %.) IR ν_{max}^{Nujol} cm^{-1}: 1750, 1650, 1605, 1260, 900 and 892. ^1H NMR: δ 6.07 and 5.37 (1H each, *d*, J = 3 Hz conjugated, α-methylene), 5.0 and 4.9 (1H each, *bs*, C-10 = CH_2), 3.90 (1H, *dd*, J = 9 and 10 Hz, C-6) and 3.27 and 2.73 (1H each, *d*, J = 5 Hz, C-4 epoxy protons). Elution of the column with petrol–Et_2O (1:1) eluted compound **5**, mp 97°. (Found: C, 68.58; H, 6.99. $C_{15}H_{18}O_4$ requires: C, 68.68; H, 6.92 %). IR ν_{max}^{Nujol} cm^{-1}: 1755, 1680, 1260, 920, 860 and 805. ^1H NMR: δ 6.22 and 5.52 (1H each, *d*, J = 4 Hz, conjugated α-methylene), 4.12 (1H, *t*, J = 10 Hz, C-6), 3.27 and 2.79 (1H each, *d*, J = 4 Hz, C-4 epoxy protons) and 2.80 (2H, *s*, C-10 epoxy protons). Eluting the column with the same solvent afforded another pure diepoxide **5**, mp 137°. (Found: C, 68.44; H, 7.0. $C_{15}H_{18}O_4$ requires: C, 68.68; H, 6.92 %). IR ν_{max}^{Nujol} cm^{-1}: 1755, 1680, 1240, 940 and 800. ^1H NMR: δ 6.2 and 5.48 (1H each, *d*, J = 3 Hz, conjugated α-methylene), 4.2 (1H, *dd*, J = 9 and 10 Hz, C-6), 3.3 and 2.8 (1H each, *d*, J = 4 Hz, C-4 epoxy protons) and 2.75 (2H, *s*, C-10 epoxy protons).

Reaction of monoepoxide **4** *with perbenzoic acid.* A $CHCl_3$ soln of compound **4** on reaction with excess perbenzoic acid followed by isolation and chromatography as reported above afforded the products with mp 97° and 137°, respectively, which were identical in all respects (mmp and IR spectra) with authentic samples.

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