Chemistry of Natural Compounds, Vol. 49, No. 1, March, 2013 [Russian original No. 1, January–February, 2013]

ELECTROCHEMICAL SYNTHESIS OF BIFLAVONOIDS

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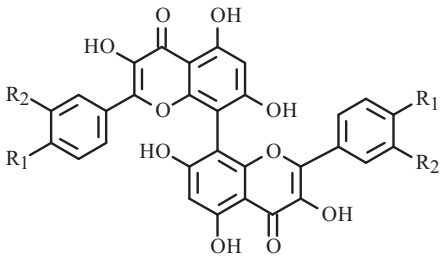
UDC 541.138.2

Biologically active biflavonoids have consistently attracted the attention of researchers [1]. However, only a few of these compounds have a broad spectrum of biological activity. This has prompted scientists to prepare their semi-synthetic and synthetic analogs [2]. Thus, several approaches including metal-catalyzed cross coupling, oxidative coupling, Ulmann condensation with nucleophiles, etc. have been used to synthesize biflavonoids [2]. We hypothesized that it would be possible to use an electrochemical method to prepare novel compounds based on flavonoids [3–5].

The flavonols isorhamnetin and kaempferide that were isolated earlier by us from *Alhagi pseudalhagi* (M. Bieb.) Fisch. were used for the synthesis. The flavonol (1 mmol) was dissolved in CH_3CN (100 mL). The electrolysis was carried out in the presence of $LiClO_4$ (0.1 M) in a cell with a diaphragm and a Pt anode of working surface 2 cm^2 and current density 5 mA/cm^2 for 3 h. When the electrolysis was finished, about 90% of the solvent was distilled off. The remainder was used to separate the products by column chromatography over silica gel. In both instances, the principal products were recrystallized from acetone to afford light-brown powders in 0.22 ± 0.05 g yields. Their physicochemical and spectral characteristics were determined by known methods.

Compound 1. $C_{32}H_{22}O_{14}$, mp 285 ± 3°C, $[\alpha]_D^{20}$ +39.7° (*c* 0.57, MeOH). UV spectrum (MeOH, λ_{max}, nm): 251, 325, 356. IR spectrum (KBr, ν_{max}, cm^{-1}): 3430, 3370 (OH), 1681, 1600 (C=O), 1607, 1570 (aromatic C=C). Mass spectrum (EI, 70 eV), *m*/*z* (I_{rel}, %): 630 (M^+, 100), 615 (13), 315 (17). PMR spectrum (400 MHz, $CDCl_3$, δ, ppm): 3.96 (6H, d, 3′, 3″-OCH_3), 6.83 (2H, s, H-6, 6″), 7.23 (2H, s, H-5′, 5‴), 7.52 (4H, s, H-2′, 6′, 2‴, 6‴), 9.35 (2H, s, OH-4′, 4‴), 10.12 (2H, s, OH-7, 7″), 10.82 (2H, s, OH-3, 3″), 12.10 (2H, s, OH-5, 5″).

Compound 2. $C_{32}H_{20}O_{12}$, mp 291 ± 3°C, $[\alpha]_D^{20}$ +38.4° (*c* 0.52, MeOH). UV spectrum (MeOH, λ_{max}, nm): 210, 271, 368. IR spectrum (KBr, ν_{max}, cm^{-1}): 3423 (OH), 1590 (C=O), 1520, 1460 (aromatic C=C). Mass spectrum (EI, 70 eV), *m*/*z* (I_{rel}, %): 596 (M^+, 100), 581 (12), 298 (22). PMR spectrum (400 MHz, $CDCl_3$, δ, ppm): 3.83 (6H, d, OCH_3-4′, 4‴), 6.83 (2H, s, H-6, 6″), 7.36 (4H, s, H-3′, 3‴, 5′, 5‴), 7.50 (4H, s, H-2′, 6′, 2‴, 6‴), 10.16 (2H, s, OH-7, 7″), 10.76 (2H, s, OH-3, 3″), 12.17 (2H, s, OH-5, 5″).



1, 2

1: R_1 = OH, R_2 = OCH_3
2: R_1 = OCH_3, R_2 = H

UV absorption maxima of the prepared compounds were characteristic of flavonoids. IR spectra of the synthesized compounds retained absorption bands corresponding to functional groups of the starting compounds. The molecular ions were the base peaks in mass spectra of **1** and **2**, which is typical of flavonoids. The *m*/*z* values for the molecular ions corresponded to dimers of the starting flavonoids. Fragments with *m*/*z* 315 and 298 were identified as radicals of isorhamnetin and kaempferide,

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 0009-3130/13/4901-0108 ©2013 Springer Science+Business Media New York

respectively. These were formed by cleavage of the interflavonoid bonds. Peaks with *m*/*z* 615 and 581 were due to fragment ions that were formed by cleavage of $CH_3^{\bullet}$ from the molecular ions. PMR spectra of the electrolysis products lacked resonances in the range 6.45–6.60 ppm corresponding to C-8 protons in the starting flavonols. This enabled us to hypothesize that these atoms were involved in the interflavonoid bonds.

Based on the results, **1** and **2** were identified as 8-8 bi-isorhamnetin and 8-8 bi-kaempferide, respectively.

REFERENCES

1. M. Sun, X. Feng, M. Yin, Y. Chen, X. Zhao, and Y. Dong, *Chem. Nat. Comp.*, **48**, 231 (2012).
2. M. Rahman, M. Riaz, and U. R. Desai, *Chem. Biodiversity*, **4** (11), 2495 (2007).
3. H. P. Hendrickson, A. D. Kaufman, and C. E. Lunte, *J. Pharm. Biomed. Anal.*, **12** (3), 325 (1994).
4. A. M. Oliveira Brett and M.-E. Ghica, *Electroanalysis*, **15** (22), 1745 (2003).
5. P. Janeiro and A. M. Oliveira Brett, *Anal. Chim. Acta*, **518** (1–2), 109 (2004).