Benz[e]isoindole

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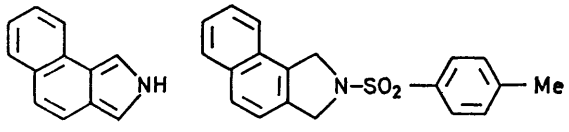
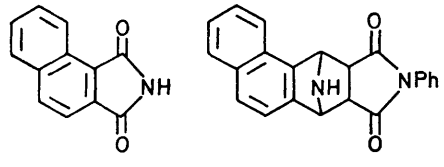
Summary Further experimental confirmation of the validity of predictions based on HMO calculations of the stability of isoindoles is provided by the synthesis of benz[*e*]isoindole, the second and simplest example to date of an isolable isoindole which is free of substituents in the pyrrole ring.

THE fact that both isoindole[1] and benz[*f*]isoindole[2] exist only in solution prompted us some time ago to examine the question of the stability of *N*-unsubstituted isoindoles by means of Hückel molecular orbital (HMO) calculations.[3] Using the calculated differences in delocalization energies of the tautomeric isoindole and isoindolenine forms of a series of both known and hypothetical isoindoles, and the stability characteristics of two reported isoindoles, *i.e.* isoindole[1] and 1-phenylisoindole,[4] we predicted that, among others, dibenz[*e,g*]isoindole should possess a high degree of stability while benz[*e*]isoindole (I) should be less stable, but isolable. The recent synthesis[5] of the remarkably stable dibenz[*e,g*]-isoindole has led us to seek further confirmation of the validity of the predicted stabilities by attempting to prepare benz[*e*]isoindole (I). It was felt that the synthesis of this compound would provide a more exacting test of the theory since the results of our calculations indicate (I) to be just slightly more stable than the highly reactive, but isolable 1-phenylisoindole. We now report the synthesis, isolation, and properties of benz[*e*]isoindole (I), which is the second example of an isoindole totally unsubstituted in the pyrrole ring.



(I) (II)



(III) (IV)

The synthesis of benz[*e*]isoindole (I) was effected by base-induced elimination of toluene-*p*-sulphinic acid from 2-toluene-*p*-sulphonylbenz[*e*]isoindoline (II). Sulphonamide (II),† m.p. 160—161° (from benzene), was obtained in 41% yield by dialkylation of toluene-*p*-sulphonamide[6] with 1,2-bis(bromomethyl)naphthalene.[7] Treatment of (II) with a three-fold excess of potassium t-butoxide in dimethyl sulphoxide afforded benz[*e*]isoindole (I) (80%), as colourless needles, m.p. 80—81°, after sublimation at 70°/1·0 mm and/or recrystallization from cyclohexane. Compound (I) reacts immediately with both Ehrlich's reagent (blue colour) and a pine splint (deep violet colour). The assignment of the structure of benz[*e*]isoindole is supported by molecular-weight determination and spectrometric data. The i.r. spectrum ($CHCl_3$) of (I) shows sharp NH absorption at 3450 cm^{-1} and its 60 MHz n.m.r. spectrum ($CDCl_3$) exhibits an aromatic multiplet centred at τ 2·5 and a broad NH signal at τ 1·34; u.v. λ_{max} ($CHCl_3$) nm (ϵ) 255 (31,200), 315 (5130), and 347 (1810).

Although compound (I) could be stored for many weeks at 0°, it quickly darkened with retention of its crystalline form on standing at room temperature. A sample of benz[*e*]isoindole exposed to air appeared as black needles after 24 h. Reduction of compound (I) was readily effected by stirring with freshly coppered zinc dust in acetic acid for 2 h at room temperature. Treatment of the crude reaction product with toluene-*p*-sulphonyl chloride in pyridine afforded the original sulphonamide (II).

Like the previously reported dibenz[*e,g*]isoindole,[5] compound (I) undergoes photo-oxidation. An oxygen-saturated 0·02 M-solution of benz[*e*]isoindole (I) in benzene was irradiated in a water-cooled quartz reactor with an Hanovia 100 w high-pressure mercury lamp for 5 h. Chromatography of the resulting solution on silica gel (benzene as eluant) afforded naphthalene-1,2-dicarboxyimide (III) (12%, from acetic acid), shown to be identical in all respects with an authentic specimen.[8]

Treatment of benz[*e*]isoindole with an excess of *N*-phenylmaleimide in deoxygenated benzene for 5 days at room temperature afforded a 1:1 adduct (48%), m.p. 189—190° (from benzene). On the basis of molecular-weight determination and u.v. and n.m.r. data, Diels–Alder structure (IV) was assigned to this adduct. The u.v. spectrum ($CHCl_3$), which shows maxima at 243 (ϵ 20,100), 293 (5350), 299 (4740), 312 (1960), 319 (125), and 327 nm (1780), is strikingly similar to the spectrum of sulphonamide (II). The absence of the isoindole nucleus in (IV) is indicated by the disappearance of the long-wavelength absorption (347 nm) observed in benz[*e*]isoindole (I) and the failure of adduct (IV) to give an immediate coloration with Ehrlich's reagent. The n.m.r. spectrum ($CDCl_3$) shows a broad NH signal at τ 7·4 (exchanges with D_2O) and signals at τ 7·05

† Satisfactory microanalyses were obtained for all new compounds.

(s, 2H, α to CO), 4·9 (s, 1H, bridgehead), 4·5 (s, 1H, bridgehead), and 2·5 (m, 11H, *ArH*). The different chemical shifts observed for the bridgehead protons are expected on the basis of the difference in deshielding of these protons by the naphthalene nucleus. Inspection of molecular models reveals that the bridgehead proton on the carbon atom bonded to the 1-position of naphthalene is more deshielded than that on the carbon atom joined to position 2.

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