Tetrahedron Letters, Vol.31, No.19, pp 2747-2750, 1990
Printed in Great Britain

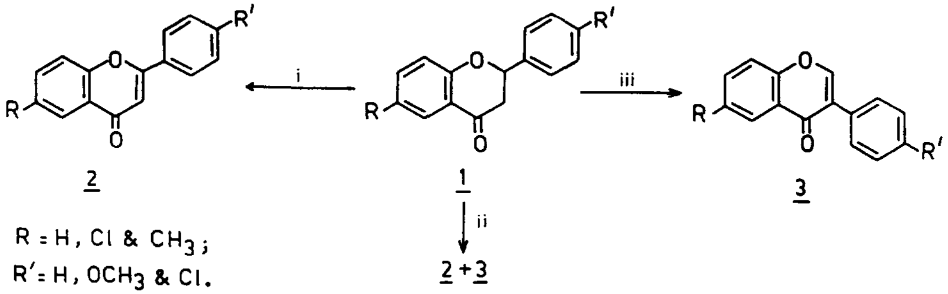
0040-4039/90 $3.00 + .00
Pergamon Press plc

Oxidative 1,2-Aryl Rearrangement in Flavanones using Thallium(III) p-Tolylsulphonate (TTS): A New useful Route to Isoflavones

Om V. Singh, C.P. Garg and R.P. Kapoor*
Department of Chemistry,
Kurukshetra University, Kurukshetra-132 119, India

Summary: Oxidation of flavanones using thallium(III) *p*-tolylsulphonate (prepared *in situ* by the reaction of thallium(III) acetate and *p*-toluene sulphonic acid) in propionitrile leads to 1,2-aryl shift providing a new useful route to the synthesis of isoflavones.

During the past two decades thallium(III) salts have been shown to be versatile reagents in organic synthesis and have been shown to affect many useful and unique transformations[1]. The synthesis of isoflavones from 2'-hydroxychalcones using thallium(III) salts in methanol[2] and flavones from flavanones using thallium(III) nitrate in methanol[3] and thallium(III) acetate (TTA) in methanol/acetonitrile/acetic acid [4] have been achieved. In view of the long known oxidation of ketones with TTA[5] and as continuation of our interest in oxidation of flavonoids [4], we have examined the behaviour of flavanones with thallium(III) *p*-tolylsulphonate (TTS) and the results are summarised in Scheme I.



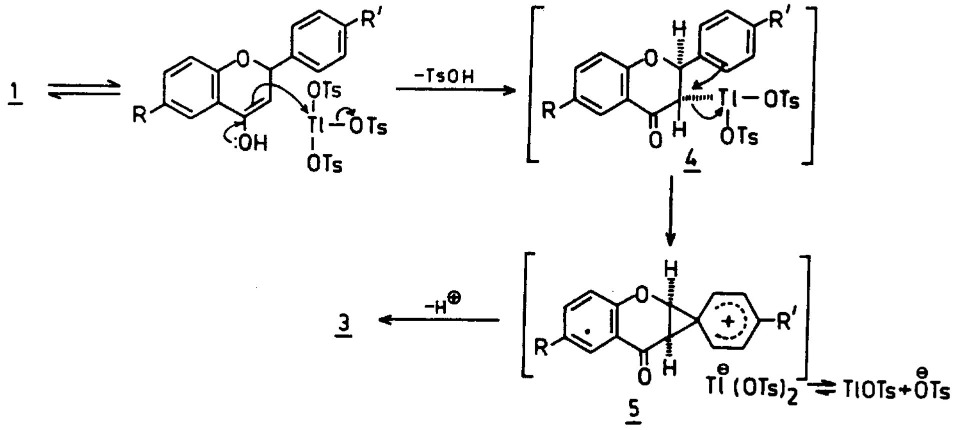
R = H, Cl & CH_3;
R' = H, OCH_3 & Cl.

i, TTA in acetonitrile/propionitrile
ii, TTA and *p*-TSA (1 equivalent) in propionitrile
iii, TTA and *p*-TSA (3 equivalents) in propionitrile

Scheme I

Thus, treatment of flavanone (1a) with TTA in presence of *p*-toluenesulphonic acid (*p*-TSA; 1 equivalent with respect to TTA) in propionitrile afforded a mixture of flavone (2a) and isoflavone (3a) in the ratio 2:1 (approximately), respectively. On increasing the amount of *p*-TSA i.e. 3 or more than 3 equivalents, the formation of only 3a was observed in almost quantitative yields. The general applicability of this transformation was established by treating other substituted flavanones (1b-g) under condition iii, when in all cases isoflavones (3b-g) were obtained. The compounds were characterised by their IR and ^{1}H-NMR spectral data and are listed in Table 1.

A plausible mechanistic course for the above transformation (1 → 3) is depicted in Scheme II.



Scheme II

The reaction is initiated by an electrophilic attack of TTS upon the enol form of 1 at the face of molecule anti to C_2-aryl ring to yield the intermediate 4. The neighbouring C_2-aryl ring helps to push out the $\overset{\ominus}{\mathrm{Tl}}(\mathrm{OTs})_2$ to form an intermediate bridged carbocation (5) which loses C_3-proton with C_2-aryl ring migration to afford 3. The 1,2-aryl shift is a favoured path because of the anchimeric assistance offered by the C_2-aryl moiety.

The above results can be rationalised by the formation of TTS in situ (cf.ref.6), by the action of p-TSA on TTA (eq.1), on the basis of following observations: (i) as observed earlier, treatment of 1 with TTA in acetonitrile/propionitrile yields only 2[4] (ii) treatment of 1 with TTA and p-TSA (1 equivalent) affords a mixture of 2 and 3 probably due to the partial conversion of TTA into TTS, both reacting with 1 giving rise to the mixture and (iii) treatment of 1 with TTA and p-TSA (3 equivalents) results in the exclusive formation of 3 (Scheme I). The above observation has indeed been found to be true as the preformed TTS, by the reaction of TTA with p-TSA in benzene, on treatment with 1 also afforded only 3.

$$Tl(OCOCH_3)_3 + 3p\text{-}CH_3C_6H_4SO_3H \longrightarrow Tl(OSO_2C_6H_4CH_3\text{-}p)_3 + 3CH_3COOH \quad ....(eq.1)$$

The present oxidative conversion of 1→3 is significant because it offers a new and convenient route to the synthesis of isoflavones from easily available flavanones and has synthetic significance as this approach may be useful for the synthesis of naturally occurring flavonoids.

Attempts to isolate and characterise TTS are being made, in addition to the studies on the effect of various solvents and other thallium(III) carboxylates or sulphonates on the course of oxidation of flavanones and chromanones. The results will be published elsewhere.

Acknowledgement : One of the authors (OVS) is thankful to CSIR, New Delhi for the award of Senior Research Fellowship.

Table-1. Oxidation of flavanones with thallium(III) p-tolylsulphonate (TTS).

Compounds	Products	Yield[a](%)	m.p (lit. m.p.) (°C)
1a=R=R'=H	3a=R=R'=H	94	131-2 (132)[7]
1b=R=H,R'=OCH_3	3b=R=H,R'=OCH_3	96	138-9 (138-40)[8]
1c=R=Cl,R'=H	3c=R=Cl,R'=H[b]	96	174-5
1d=R=Cl,R'=OCH_3	3d=R=Cl,R'=OCH_3[b]	94	194-5
1e=R=CH_3,R'=H	3e=R=CH_3,R'=H	92	108-9 (108)[9]
1f=R=CH_3,R'=OCH_3	3f=R=CH_3,R'=OCH_3[b]	94	123-4
1g=R=CH_3,R'=Cl	3g=R=CH_3,R'=Cl[b]	90	205-6

a) The yields are based upon isolated solid products.

b) Satisfactory spectral data and C & H analysis were obtained.

References:

1. R.J.Ouellette, "Oxidation in Organic Chemistry", W.S.Trahanovsky, Ed., Academic Press, New York, Part B, 173 (1973); A. McKillop,and E.C.Taylor Adv. Organomet. Chem.,11, 147 (1973); A. McKillop, Pure Appl. Chem.,43, 463 (1975); A. McKillop and E.C.Taylor, Endeavor, 35, 88 (1976); S.Uemura, "Synthetic Reagents", J.S. Pizey, Ed., Ellis Horwood, Chichester, 5, 165 (1981).

2. W.D.Ollis, K.L.Ormand and I.O.Sutherland, J.Chem. Soc., Chem. Commun., 1237 (1968); L.Farkas, A. Gottesegen and M.Nogradi, J.Chem.Soc.,Perkin Trans.I, 306 (1974); S.Antus, L.Farkas, M.Nogradi and P.Sohar, J.Chem. Soc.,Chem. Commun., 799 (1974); S.Antus and M.Norgadi, Chem. Ber., 112, 480 (1979).

3. R.S.Verma and M.Verma, Synthetic Commun., 12, 927 (1982).

4. O.V.Singh and R.P. Kapoor, Tetrahedron Lett., in Press (1990).

5. S.Uemura, T.Nakano and K.Ichikawa, J.Chem.Soc.Jap., 88, 1111 (1967); N.Malaitong and C.Thebtaranonth, Chem. Lett., 305 (1980); A Romeo and G.Ortar, Tetrahedron, 28, 5337 (1972).

6. The reaction of TTA with carboxylic acids in benzene gives the corresponding thallium(III) carboxylates; J.K. Kochi and T.W. Bethea, III, J.Org. Chem., 33, 75 (1968).

7. P.C. Joshi and K.Venkataraman, J. Chem. Soc., 513 (1934).

8. S.C.Bharara, A.C. Jain and T.R. Seshadri, Tetrahedron, 21, 963 (1965).

9. Le-Van-Thoi and Nguyen-Van-Hong, Vietnamica Chim.Acta, 87 (1966); Chem. Abstr., 71, 124127_g (1969).

(Received in UK 21 March 1990)