Synthesis of Fluorenebisphenoxy Derivatives by Acid-sulfur Compound Catalyzed Condensation Reaction

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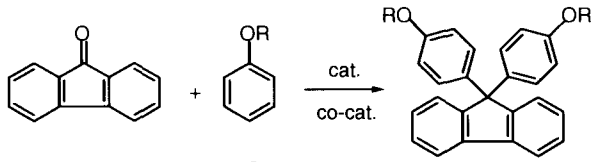
An efficient method for the synthesis of fluorenebisphenoxy derivatives from fluorenone and phenoxy compounds is successfully performed by the combined use of concentrated sulfuric acid as catalyst and 3-mercaptopropionic acid as co-catalyst. Several fluorenebisphenoxy derivatives are obtained in good yields by this one-step reaction.

Fluorenebisphenoxy derivatives have attracted much attention because of their potential use as precursors of several functional polymers.[1,3] Previous methods for the synthesis of this kind of compounds include condensation of fluorenone and phenol in the presence of hydrogen chloride for 2 days,[2] affording the 9, 9-bis(4-hydroxyphenyl)fluorene in 46% yield, following by treatment with ethylene oxide.[3] These methods require the use of hazardous reagents, involve multi-steps procedures, and give modest yields. Therefore, the development of general and efficient method for the preparation of fluorenebisphenoxy derivatives is desired. In this communication, we would like to report a new method for the synthesis of fluorenebisphenoxy derivatives **3** starting from fluorenone **1** and phenoxy compounds **2**, by the combined use of 3-mercaptopropionic acid as co-catalyst and concentrated sulfuric acid as catalyst (Scheme 1).



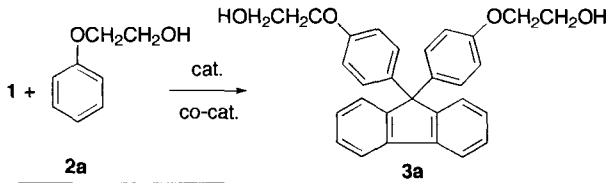
1 2 3

Scheme 1.

In general, the condensation activity of fluorenone **1** with phenoxy compounds **2** decreases as compared with normal ketones.[4] This stability is attributed to the high aromaticity in fluorenone structure. We found that fluorenone **1** could not be efficiently activated by the use of acid alone. Therefore, it is expected that the activation of fluorenone would proceed smoothly by use of co-catalyst. At first, the effect of co-catalyst was examined taking the condensation reaction of fluorenone **1** with phenoxyethanol **2a** as model.[5] The reaction was carried out in the presence of 10.6 wt% of concentrated sulfuric acid as catalyst, 0.08 wt% of divalent sulfur compound such as thiophenol, thioacetic acid and 3-mercaptopropionic acid as co-catalyst (Table 1). As a result, a remarkable effect of 3-mercaptopropionic acid was observed among three sulfur compounds. Then several kinds of protonic acids were examined and concentrated sulfuric acid was found to be the only effective catalyst for the condensation reaction (Table 1). Secondly, the molar ratio of reactants, temperature and reaction time were examined in order to improve the yield (Table 2). As the best result, a high yield (94.9%) was achieved when the reaction was carried out in fluorenone **1**/ phenoxyethanol **2a** (1:4) at 65 ℃ for 5 h.

The reaction can be explained by assuming the mechanism shown in Scheme 2. The function of 3-mercaptopropionic acid

Table 1. Effects of co-catalysts and catalysts[a]



2a **3a**

Co-catalyst	Catalyst	Yield/%[b]
None	H_2SO_4(conc.)	No reaction
PhSH	H_2SO_4(conc.)	64.2
CH_3COSH	H_2SO_4(conc.)	71.6
$HSCH_2CH_2CO_2H$	H_2SO_4(conc.)	94.9
$HSCH_2CH_2CO_2H$	CH_3SO_3H	No reaction
$HSCH_2CH_2CO_2H$	CF_3SO_3H	No reaction

[a]The reaction of **1** (1.0 equiv.) and **2a** (4.0 equiv.) were carried out at 65°C for 5 h.
[b]Determined by HPLC based on fluorenone used.

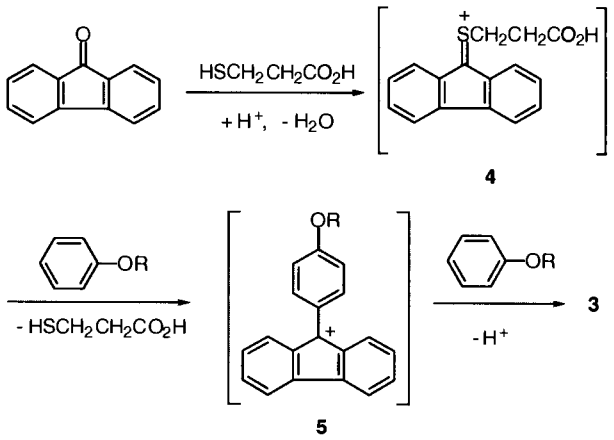
Table 2. Effects of molar ratio of **2a** to **1**, temperature and time

1 + **2a** $\xrightarrow[HSCH_2CH_2CO_2H]{H_2SO_4(conc.)}$ **3a**

2a / **1**	Temp(°C)	Time(h)	Yield/%[a]	Isolated yield/%[b]
3.0	65	5	84.6	43.1
4.0	65	5	94.9	73.8
5.0	65	5	86.5	39.1
4.0	50	5	81.5	52.0
4.0	80	5	90.8	66.2
4.0	100	5	79.4	52.5
4.0	65	8	92.0	63.1

[a]Determined by HPLC based on fluorenone used.
[b]Recrystallized from toluene.

could be reasonably interpreted in terms of the formation of reactive intermediate **4**, which is an active species to phenoxy compounds **2**. The formation of reactive intermediate **4** proceeds with elimination of water, this water was removed rapidly by concentrated sulfuric acid. On the other hand, concentrated sulfuric acid can also stabilizes another transient intermediate **5**. Therefore, concentrated sulfuric acid was found to be the most efficient catalyst.



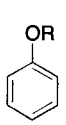
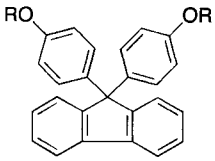
Scheme 2.

Several examples of present condensation reaction are demonstrated in Table 3. The desired fluorenebisphenoxy derivatives **3** were obtained in good yield by the condensation of fluorenone **1** with the corresponding phenoxy compounds **2**.

The typical experimental procedure is as follows: to a mixture of fluorenone (45.0 g, 0.25 mol), phenoxyethanol (138.0 g, 1.00 mol) and of 3-mercaptopropionic acid (0.16 g, 0.0015 mol) was successively added concentrated sulfuric acid (21.7 g, 0.22 mol) over 30 min. The reaction mixture was stirred for 5 h at 65 °C, then it was quenched by adding methanol (300 ml). The precipitate was recovered by filtration and washed with water. After drying, resulting residue was recrystallized from toluene (500 ml) to give pure **3a** (81.5 g, 73.8% yield).

Thus, a new and efficient method for the synthesis of fluorenebisphenoxy derivatives from fluorenone and phenoxy compounds is successfully performed by the combined use of 3-mercaptopropionic acid as co-catalyst and concentrated sulfuric acid as catalyst. It is noted that this synthetic method can be applied to industrial production of fluorenebisphenoxy derivatives, those can be utilized for the synthesis of useful polymers.

Table 3. Syntheses of fluorenebisphenoxy derivatives **3**

Phenoxy compound	Product	Yield/%[a]
		
2a (R=-CH_2CH_2OH)	**3a**	73.8
2b (R=-$CH_2CH(OH)CH_3$)	**3b**	66.4
2c (R=-$CH_2CH_2CO_2CH{=}CH_2$)	**3c**	64.2
2d (R=-$CH_2CH_2CO_2H$)	**3d**	70.5
2e (R=-$CH_2CH_2CH_2Br$)	**3e**	62.3

[a]Isolated yield.

References and Notes

1 For example, see a) C. S. Chen, B. J. Bulkin, and E. M. Pearce, *J. Appl. Polym. Sci.*, **27**, 1177 (1982). b) C. S. Chen, B. J. Bulkin, and E. M. Pearce, *J. Appl. Polym. Sci.*, **27**, 3289 (1982). c) J. Lo, S. N. Lee, and E. M. Pearce, *J. Appl. Polym. Sci.*, **29**, 35 (1984). d) Y. J. Li, M. Yamada, Y. F. Wang, T. M. Chen, and T. Nakaya, *Chem. Mater.*, **8**, 1441 (1996).

2 P. W. Morgan, *Macromolecules*, **3**, 536 (1970), and references therein.

3 G. S. Papava, N. A. Maisuradze, Z. L. Zarkua, N. S. Dokhturishvili, Z. M. Sarishvile, G. B. Razmadze, S. V. Vinogradova, and V. V. Korshak, *Acta. Polymerica.*, **8**, 445 (1988).

4 For a review, see H. Schnell and H. Krimm, *Angew. Chem. Internat. Edit.*, **2**, 373 (1963).

5 Fluorenone **1** was prepared by oxidation of fluorene: K. Hashimoto, M. Yamada, K. Okimi, S. Uzu, and Y. Suda, Japanese Patent 211729 (1994).