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THE REACTIONS OF BIVALENT SULFUR COMPOUNDS-COPPER(II) COMPLEXES: THE BENZYLATION OF AROMATIC COMPOUNDS WITH BENZYL SULFIDES

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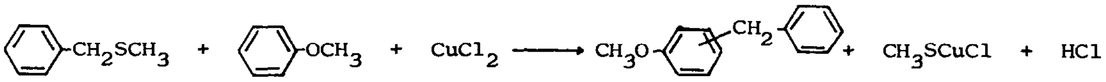
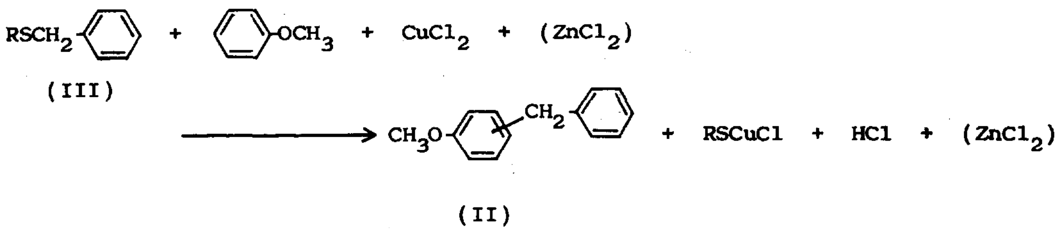
Recently it was found in our laboratory that coordinated compounds of mercaptals or mercaptoles and $CuCl_2$ react with nucleophiles such as anisole and active methylene compounds to give the corresponding condensation products under mild conditions[1]. The new synthetic reaction with bivalent sulfur compounds-copper(II) complexes was further extended to the reaction with alkyl sulfides according to the expectation that the sulfides would be activated by the coordination with Cu(II) to react with aromatic compounds such as anisole, m-xylene, toluene and benzene, yielding the alkylated products. First, the reaction of benzyl methyl sulfide(I) with anisole was examined. The sulfide(I) was refluxed in anisole in the presence of an equimolar amount of $CuCl_2$ for 13 hours, and anisylphenylmethane(II, bp 115-116°/1.5 mmHg) was obtained in 53% yield with the evolution of hydrogen chloride.

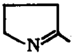
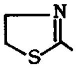
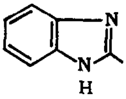
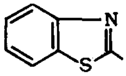
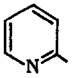


(I) (II)

Next, in order to improve the yield of the benzylated product, a variety of benzyl sulfides(III), in which $RS^{\ominus}$ would be more stabilized by the resonance effect upon the elimination of benzyl group, were used in place of I in the above reaction. In fact, when III were allowed to react with anisole in the presence of an equimolar amount of $CuCl_2$ in refluxing anisole for 5 hours, the benzylated product(II) was obtained as shown in Table 1.

Table 1



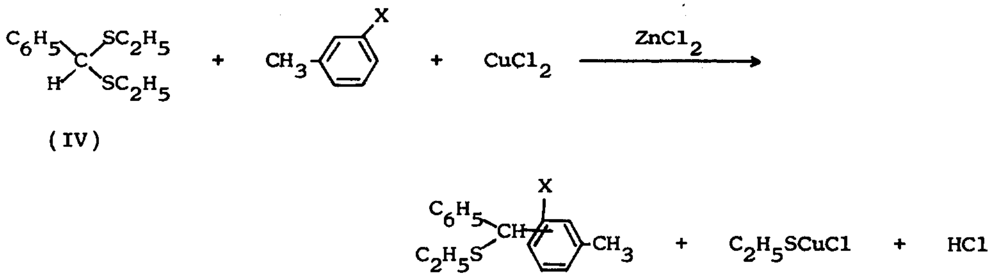
	III	II Yield (%)	
	R-	CuCl$_2$ only	CuCl$_2$ + ZnCl$_2$
a)		17	34
b)		18	57
c)		28	61
d)		6	66
e)		2	79
f)		34	79

The low yields of II, as described in Table 1, would indicate that the facility of CuCl$_2$ in activating the sulfides(III) would not be so sufficient for the generation of benzyl cation when the complex is attacked by anisole.

In order to decrease the electron density of benzylic carbon, ZnCl$_2$ which would presumably coordinate to the ring nitrogen atom was used together with CuCl$_2$. When 4- and 2-benzylthiopyridines(IIIe and f) were refluxed in anisole for 5 hours in the presence of both a catalytic amount of $ZnCl_2$ and an equimolar amount of $CuCl_2$, II was obtained in 23% and 31% yields, respectively. Further, it was established that in the presence of equimolar amounts of $ZnCl_2$ and $CuCl_2$, the yields of II increased up to 79% with respect to both IIIe and IIIf. The other sulfides(IIIa-d) also reacted with anisole in a similar manner, and II was produced in higher yields than in the case of using $CuCl_2$ alone. The isomer ratio (para to ortho) of II was determined to be about 2 by NMR and gas chromatographic determinations. On the other hand, when $AlCl_3$, $SnCl_4$, $FeCl_3$ and $Et_2O \cdot BF_3$ were substituted for $ZnCl_2$ and used together with $CuCl_2$, II was isolated in only a few percent yield and when only $ZnCl_2$ was used, II could not be detected. In conclusion, it was found that the reaction of sulfides(III) with anisole proceeds effectively in the presence of equimolar amounts of $ZnCl_2$ and $CuCl_2$ giving the substituted product(II).

This reaction was further applied to other aromatic compounds such as m-xylene, toluene and benzene, and benzylated products, phenylxylylmethane (bp 115°/3 mmHg; 2- and 4-isomers in a ratio of 2:13), phenyltolylmethane (bp 109-109.5°/3.5 mmHg; ortho and para isomers in a ratio of 5:4) and diphenylmethane (bp 83°/4 mmHg) were obtained in 54%, 34% and 15% yields, respectively, by the treatment with 4-benzylthiopyridine.

The procedure using $ZnCl_2$ together with sulfide-Cu(II) was further applied to other bivalent sulfur compounds such as benzaldehyde diethylmercaptal(IV) and benzyl methyl sulfide(I). In a previous paper, it was reported that the reaction of IV with anisole in the presence of $CuCl_2$ gave the substituted product[1] in a good yield. But, when m-xylene and toluene were used in place of anisole, the reaction did not occur and the starting materials were recovered. On the contrary, when IV was stirred in m-xylene or toluene in the presence of equimolar amounts of $ZnCl_2$ and $CuCl_2$ for 5 hours at room temperature, the substituted products, phenylxylylmethyl ethyl sulfide (Va, bp 165°/4 mmHg) and phenyltolylmethyl ethyl sulfide (Vb, bp 150-151°/4 mmHg) were obtained in 16% and 11% yields, respectively. In the presence of two equimolar amounts of $ZnCl_2$ and $CuCl_2$, Va and Vb were obtained in 8% and 20% yields, respectively.



(IV)

Va, $X=CH_3$

Vb, $X=H$

Next, the reaction of benzyl methyl sulfide(I) with anisole was reexamined in the presence of equimolar amounts of $ZnCl_2$ and $CuCl_2$ in refluxing anisole. The evolution of hydrogen chloride was much more vigorous than observed in the reaction by using $CuCl_2$ alone described before, and ceased only after a few hours. The substituted product(II) was obtained in higher yield (76%) after the reaction mixture was refluxed for 5 hours.

In summary, it was found that the reaction of sulfides(I, III and IV) with aromatic compounds proceeds easily by the combined use of equimolar amounts of $ZnCl_2$ and $CuCl_2$ but in the case of $CuCl_2$ and other Lewis acids, the reaction scarcely proceeded, and in the case of $ZnCl_2$ alone, the reaction did not occur. From these results $ZnCl_2$ appears to participate only in the activation of $CuCl_2$-sulfide complex or $CuCl_2$.

REFERENCES

1. T. Mukaiyama, K. Narasaka and H. Hokonoki, J. Am. Chem. Soc. 91, 4315 (1969); T. Mukaiyama, K. Narasaka, K. Maekawa and H. Hokonoki, Bull. Chem. Soc. Japan, 43, 2549 (1970).