Convenient method for acetylation of alcohols with $[\text{Cu}_4\text{(tu)}_4\text{Cl}_4]$  

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**ABSTRACT**  
In this research transformation of alcohol to the corresponding acetates carried out using $[\text{Cu}_4\text{(tu)}_4\text{Cl}_4]$ at 50°C in acetic anhydride without NaBH$_4$ in high to excellent yields.  

**KEYWORDS**  
Copper-thiourea complex; Alcohols; Acetic anhydride.

**INTRODUCTION**  
The conversion of alcohols to esters is an important synthetic transformation that has received considerable attention$^{[1,2]}$. Conversion of an alcohol to the corresponding acetate is typically carried out using acetic anhydride or acetyl chloride in the presence of pyridine or triethylamine as a catalyst$^{[3,4]}$. 4-(Dimethylamino)pyridine is known to cause a remarkable rate acceleration in the reaction$^{[5]}$. In addition to catalysis by tertiaryamines, Lewis acids have also been reported to catalyze the acetylation of alcohols. Examples include TMSCI$^{[6]}$, MgBr$_2$$^{[7]}$, Sc(ACO)$_3$-$\text{(CF}_2\text{SO}_3\text{)}_2\text{NH}^{[8]}$, TiCl$_4$, AgClO$_4$$^{[9]}$, CoCl$_2$$^{[10]}$, as well as Sn(OTf)$_2$, Cu(OTf)$_2$ and In(OTf)$_3$$^{[11-13]}$. A highly efficient catalyst, Sc(OTf)$_3$, was introduced by Yamamoto$^{[14]}$. However most of the reported methods suffer from one or more of the following disadvantages: long reaction time, vigorous reaction conditions, the occurrence of side reactions and unavailability of the reagents, as well as poor yields of the desired product. Thus, there is still a demand to develop new and mild methods for the acetylation of alcohols in the presence of in expensive and bench top reagents$^{[15-17]}$. Transformation of alcohols to acetyl esters is one of the most important methods which has been received considerable attentions in organic synthesis specially in protection of functional groups. This goal was carried out in the presence of various reagents in acetic anhydride as a source of acetyl moiety$^{[18,19]}$. Here in, we wish to report a clean, simple and efficient protocol for acetylation of alcohols using $[\text{Cu}_4\text{(tu)}_4\text{Cl}_4]$ in Ac$_2$O.

**EXPERIMENTAL**  
All reagents and substrates were purchased from commercial sources with high quality and used without further purification. The products were characterized by their $^1\text{HNMR}$ or IR spectra and comparison with the authentic samples (melting or boiling points). Organic layers were dried with anhydrous sodium sulfate before concentration in vacuum. All yields referred to isolated pure products. TLC accomplished the purity determination of the substrates and products over silica gel GF$_{254}$ aluminum sheets.

**Preparation of catalyst $[\text{Cu}_4\text{(tu)}_4\text{Cl}_4]$**  
A hot solution of thiourea (0.89 g, 11.69 mmol) in ethanol (15 mL) was added into a hot solution of cop-
per chloride dihydrate (1.008 g, 5.91 mmol) in ethanol (15 mL). The mixture was stirred and refluxed for 1h to
give white solid suspension. The solution was filtered while hot and was allowed to cool to room tempera-
ture. The product was filtered, washed twice with etha-

Reduction of alcohols to acetates with [Cu₄(tu)₄Cl₄] in acetic anhydride

In a round-bottom flask (10 mL) equipped with a
magnetic stirrer, a mixture of benzyl alcohol (0.106 g,1 mmol) in Ac₂O (1.5 mL) was prepared. [Cu₄(tu)₄Cl₄]
(0.08 mmol) was then added and the resulting mixture
was stirred for 45 min in 50°C. TLC monitored the
progress of the reaction (eluent: CCl₄/Et₂O, 5/2) was
extracted with CH₂Cl₂ (3 × 5 mL), dried over anhydrous
Na₂SO₄. Evaporation of the solvent affords the pure
benzyl acetate in 87% yield (TABLE 1, entry 1).

Selected data for benzyl acetate (1)

FT-IR (cm⁻¹): 3050, 2980, 1720, 1403, 1367, 1225, 1043, 755, 689.¹H NMR (300 MHz, CDCl₃, δppm): δ2.18, 5.18, 7.42.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 21.01, 65.32, 124.98, 127.66, 126.87, 139.43, 169.92.

Selected data for 2-Chlorobenzyl acetate (2)

FT-IR (cm⁻¹): 3058, 2961, 1749, 1447, 1380, 1233, 1037, 757.¹H NMR (300 MHz, CDCl₃, δ ppm): δ 2.15, 5.23, 7.37.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 20.876, 64.638, 126.939, 128.246, 128.710, 129.563, 133.653, 170.695.

Selected data for 2-phenyl ethyl acetate (3)

FT-IR (cm⁻¹): 3063, 2957, 1739, 1496, 1454, 1368, 1240, 1124, 1035, 748, 700, 641, 571.¹H NMR (300 MHz, CDCl₃, δppm): δ 0.013, 2.937, 4.341, 7.09 to 7.56.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 21.92, 37.01, 66.89, 127.59, 129.76, 129.89, 138.67, 172.01.

Selected data for geraniol acetate (4)

FT-IR (cm⁻¹): 2968, 2923, 1740, 1441, 1373, 1234, 1024, 956, 829, 605, 453.¹H NMR (300 MHz, CDCl₃, δ ppm): δ 1.85, 1.98, 2.14, 2.52, 2.89, 4.98, 5.078.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 17.65, 17.98, 21.05, 26.87, 27.77, 40.54, 62.69, 118.97, 125.29, 133.56, 142.97, 171.99.

Selected data for 4-methoxy benzyl acetate (5)

FT-IR (cm⁻¹): 2967, 2845, 1742, 1618, 1521, 1242, 1177, 1031, 824.¹H NMR (300 MHz, CDCl₃, δ ppm): δ 2.18, 3.93, 5.65 6.50, 7.65.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 22.74, 57.17, 68.21, 123.94, 128.59, 132.79, 161.11, 172.52.

Selected data for furfuryl acetate (6)

FT-IR (cm⁻¹): 2971, 1742, 1625, 1503, 1434, 1373, 1237, 1152, 1021, 919, 817, 747.¹H NMR (300 MHz, CDCl₃, δ ppm): δ 2.077, 5.69, 6.92, 7.03, 7.91.¹³C NMR (62.5 MHz, DMSO-d₆, δ ppm): δ 22.65, 59.09, 111.71, 145.36, 150.72, 171.29.

RESULTS AND DISCUSSION

In course of our studies to explore more potentiali-
ties of [Cu₄(tu)₄Cl₄] in organic synthesis, we found that acetyl-
ation of benzyl alcohol with [Cu₄(tu)₄Cl₄] in ace-
TABLE 1: Acetylation of alcohols with [Cu \((tu)_4\)Cl]$_4$

<table>
<thead>
<tr>
<th>Entry</th>
<th>Substrate</th>
<th>Product</th>
<th>Time(min)</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CH$_2$OH</td>
<td>CH$_2$OAc</td>
<td>54</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>CH$_2$OH</td>
<td>CH$_2$OAc</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>Cl-CH$_2$OH</td>
<td>Cl-CH$_2$OAc</td>
<td>49</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td>CH$_2$CH$_2$OH</td>
<td>CH$_2$OAc</td>
<td>78</td>
<td>91</td>
</tr>
<tr>
<td>5</td>
<td>CHCH$_2$OH</td>
<td>CHCH$_2$OAc</td>
<td>65</td>
<td>86</td>
</tr>
<tr>
<td>6</td>
<td>CHCH$_2$CH$_3$</td>
<td>CHCH$_2$CH$_3$OAc</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>H$_3$C-C$\equiv$C-C$\equiv$C-H$_3$</td>
<td>H$_3$C-C$\equiv$C-C$\equiv$C-H$_3$OAc</td>
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<td>92</td>
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<tr>
<td>10</td>
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<td>OAc</td>
<td>76</td>
<td>93</td>
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<tr>
<td>11</td>
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<tr>
<td>12</td>
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<td>OAc</td>
<td>52</td>
<td>90</td>
</tr>
</tbody>
</table>

All reactions were carried out at 50°C and with 0.08 mmol of [Cu \((tu)_4\)Cl]$_4$. This resulted in the conversion of 1 mmol benzyl alcohol to benzyl acetate being carried out perfectly within 54 min. This prompted us to investigate the capability of this system for acetylation of various aliphatic and benzylic
alcohols to their corresponding acetates under the optimized conditions. The results of this investigation are summarized in TABLE 1. As shown, all reactions were completed with 0.08 mmol of \([Cu_4(tu)_4Cl_4]\) within 45-80 min to give the corresponding acetates in 86-94 yields (Scheme).

\[
\begin{align*}
\text{CH}_2\text{OH} & \quad \text{Ac}_2\text{O} \\
0.08 \text{ mmol}[Cu_4(tu)_4Cl_4] & \quad 54\text{min}/50^\circ\text{C}/87\% \\
\rightarrow & \quad \text{CH}_2\text{OOCCH}_3
\end{align*}
\]

CONCLUSION

In conclusion, we have developed an efficient and excellent yielding method for the acetylation of alcohols with acetic anhydride under mild reaction conditions. The reactions are clean and no detectable by product was found. The products are obtained good to high yields and the procedure is easy.

ACKNOWLEDGMENTS

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REFERENCES