Honors Cup Synthetic Proposal

Section: 221
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Title: Synthesis of Vanillin from Catechol

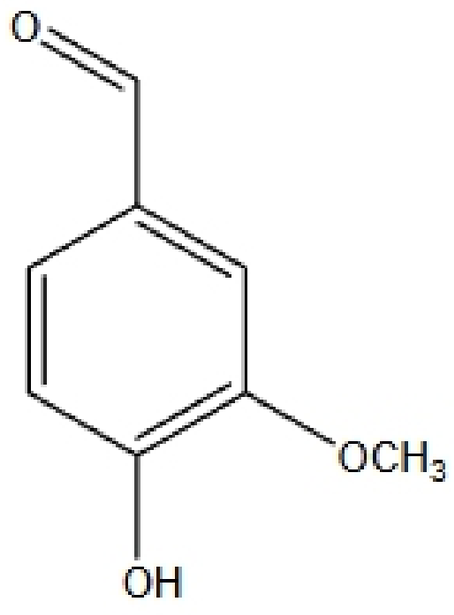
Introduction:

Vanillin (*4-hydroxy-3-methoxybenzaldehyde*) is a synthetic compound used extensively as a flavoring agent in many foods like chocolate, ice cream, and baked goods. It is also used for its pleasant scent in perfumes and is a flavoring agent in beverages. A large amount of vanillin (about 40% of all synthesized) is used as a pharmaceutical intermediate as well.

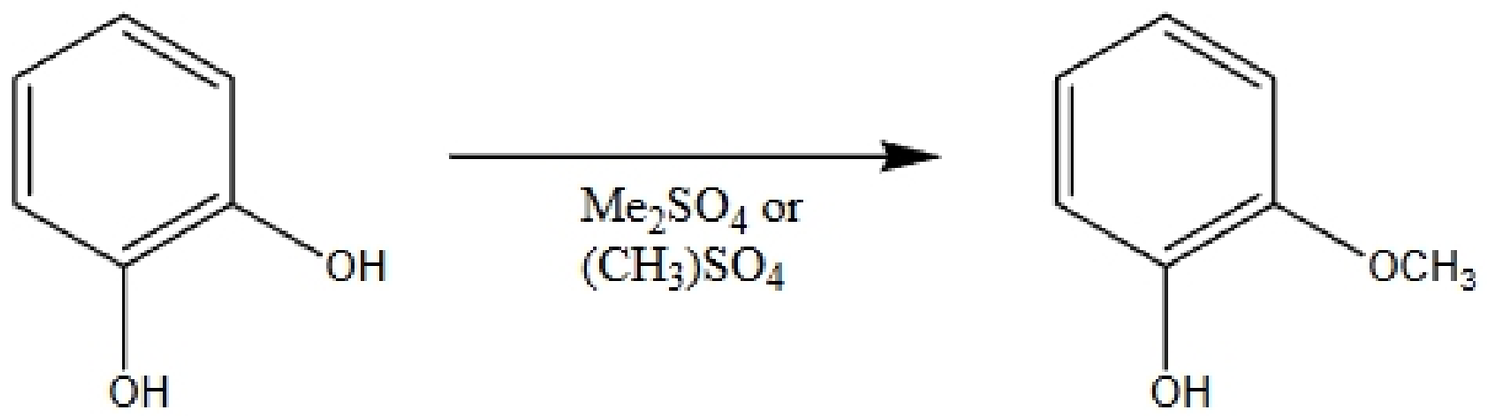
Vanillin is available from three different sources: the vanilla bean itself, from guaiacol, or from lignin. The following synthesis uses, as most of the chemical industry does, the guaiacol route. However, to be more cost efficient, we will synthesize guaiacol from catechol. Thus, the first step of the synthesis will be making guaiacol from catechol. Then, the guaiacol will be changed into vanillylmandelic acid (VMA). Finally, the VMA will be converted into vanillin.

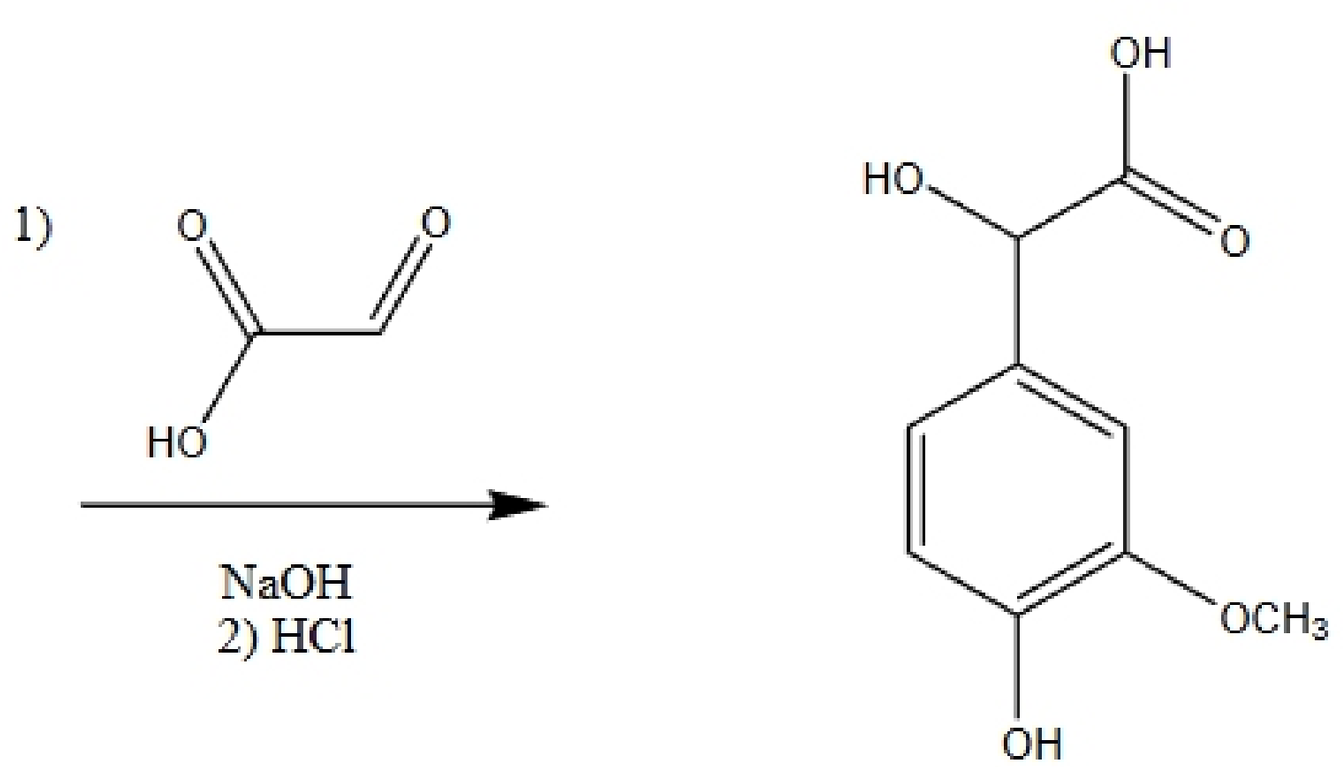
Target Molecule:

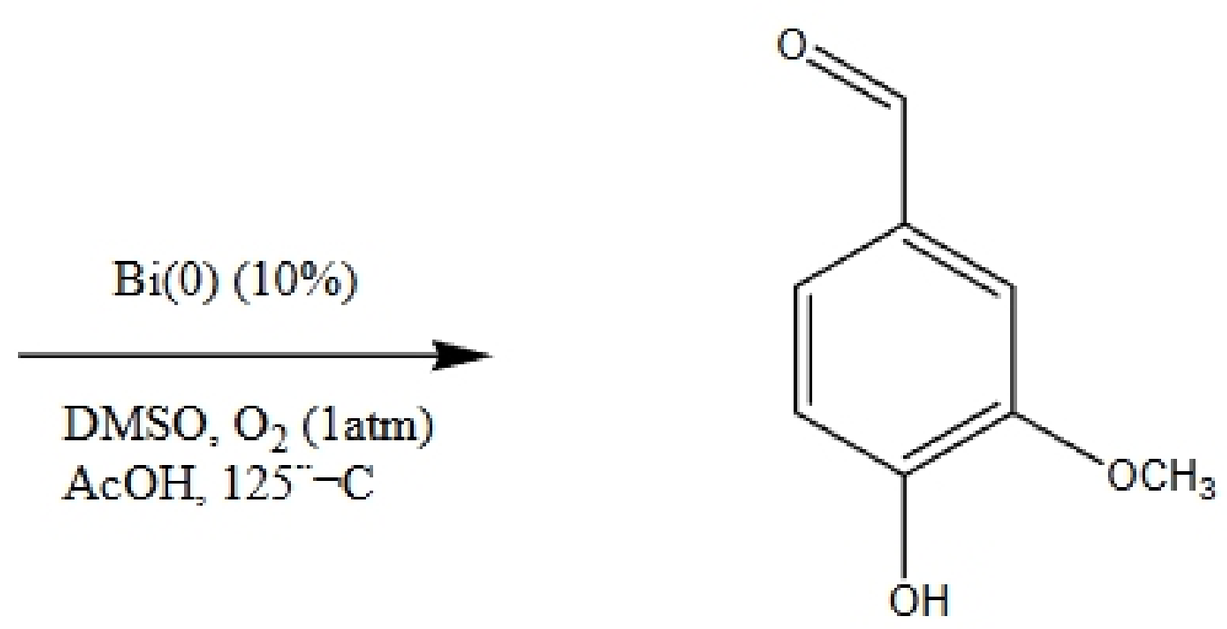
Vanillin
4-hydroxy-3-methoxybenzaldehyde ($C_8H_8O_3$)



Overall synthetic reaction scheme:

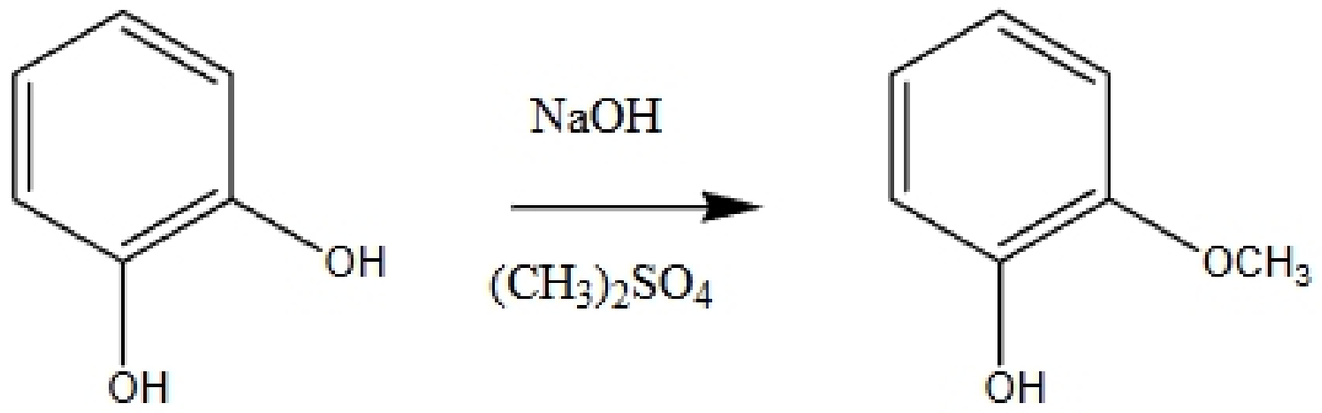






Step 1

Synthetic transformation 1:



Experimental 1

Monomethylation of Catechol

All reagents were obtained from commercial suppliers and used without further purification. 0.10 mol of catechol was added to a solution of NaOH (40%, 10 mL, 0.1 mol) and dissolved under heating. Water was evaporated under reduced pressure. Polyethylene glycol – PEG400 – (1.6 grams or about 0.04 mol) and .11 mol of dimethyl sulfate were added to the reaction system while vigorously stirring. The reaction was heated and monitored with TLC until the conversion of phenol was complete. Then, the mixture was poured into a hot NaOH solution (5%) or water (80-90 degrees Celsius, 100 mL) with stirring. The mixture was allowed to precipitate or separate into layers. The precipitate or organic layer was then washed with water (3x50mL). If a higher purity is desired, recrystallisation with a suitable solvent or distillation in vacuum may be used.

Expected yield: 86%

Safety, disposal and green issues 1:

Safety

Safety is a concern when dealing with many aromatic compounds, and catechol is no different. It is stable but care should be taken to limit exposure to air and light. It is a mutagen, tumorigen, and reproductive effector. It may also cause burns. It is harmful when inhaled, ingested, or absorbed by the skin. Dimethyl sulfate is a dangerous chemical. It is extremely toxic and carcinogenic as well as flammable. It is very important to wear goggles, gloves, cap the bottle, and keep it under a hood when dealing with these chemicals. Sodium hydroxide is very corrosive and should be used with care also.

Disposal

When disposed of, catechol should be separated from strong oxidants and kept in the dark. Ventilation is also suggested. Sodium hydroxide should be stored in a container with similar bases. Dimethyl sulfate should be in a dry, well-ventilated area with containers closed. It should