

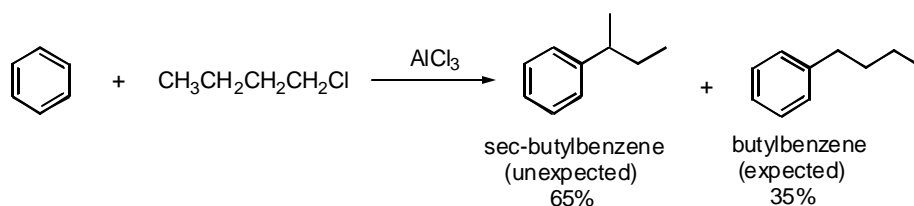
THE FRIEDEL-CRAFTS ALKYLATION AND ITS LIMITATIONS

The Friedel-Crafts reaction is a convenient way to introduce alkyl groups in the benzene ring. It is a typical electrophilic substitution process, in which the electrophile is (in most cases) a carbocation. There are three ways to generate the carbocationic species:

1. Via preliminary reaction of an alkyl chloride with AlCl_3 .
2. Via preliminary reaction of an alcohol with a Lewis acid (such as BF_3) or a Brønsted acid (usually H_3PO_4).
3. Via preliminary reaction of an alkene with a Brønsted acid, whose anion is a weak nucleophile (often HF).

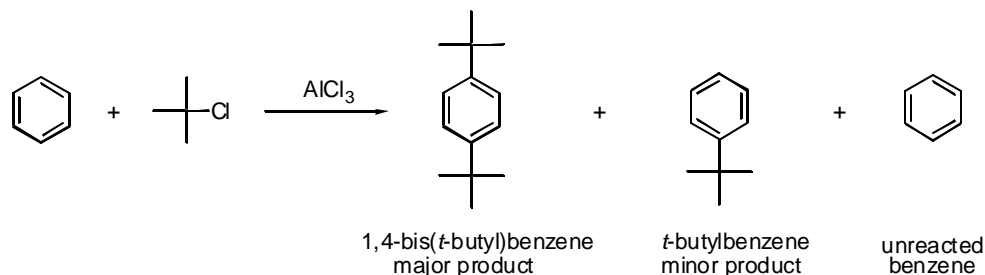
The Friedel-Crafts reaction is, however, the subject of four somewhat strict limitations:

1. The reaction works only with benzene or ACTIVATED benzene derivatives. It will not occur if the benzene ring is DEACTIVATED.
2. The reaction works only with ALKYL halides (i.e. chlorides, bromides or iodides), but it does not work with VINYL or ARYL halides.
3. Because of the intermediate formation of carbocations, product mixtures might be obtained, due to rearrangements of the carbocations. The following reaction is an illustration:



That is why the Friedel-Crafts reaction is almost useless for the preparation of derivatives with primary alkyl groups, since the expected product is either minor or not present at all.

4. The Friedel-Crafts reaction often leads to the introduction of more than one alkyl group in the molecule. The reason for such undesired polyalkylation is as follows: Upon introduction of one alkyl group, the resultant compound becomes more activated than the starting material and actually reacts faster with the electrophile, leading to the almost inevitable second alkylation. Thus, if we react one mole of benzene and one mole of *t*-butyl chloride, in the presence of AlCl_3 , the following outcome is observed:



This limitation can be avoided in particular cases, if benzene (or the benzene derivative) is used in very large excess. Such approach is of course not always practical, due to availability of the particular benzene derivative.

Limitations 3) and 4) are successfully addressed by the related process of Friedel-Crafts acylation.