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Introduction

What is organic chemistry? If you have ever taken a lab course in organic chemistry, you know that it is very much about "reactions." "Running a reaction" means that you mix chemicals so that they can react with each other while you check ("monitor") what is happening with an analytical method. You then "work up" the mixture, meaning that you take care of any new chemical that has been produced and remove any remaining unwanted chemicals, by-products, solvents, etc. Finally, you check the purity and identity of the new chemical(s) with some analytical method(s), and document your actions and results in a notebook or something similar. Taken together, the "running" and "workup" is called "performing a synthetic step" (Figure 1.1).

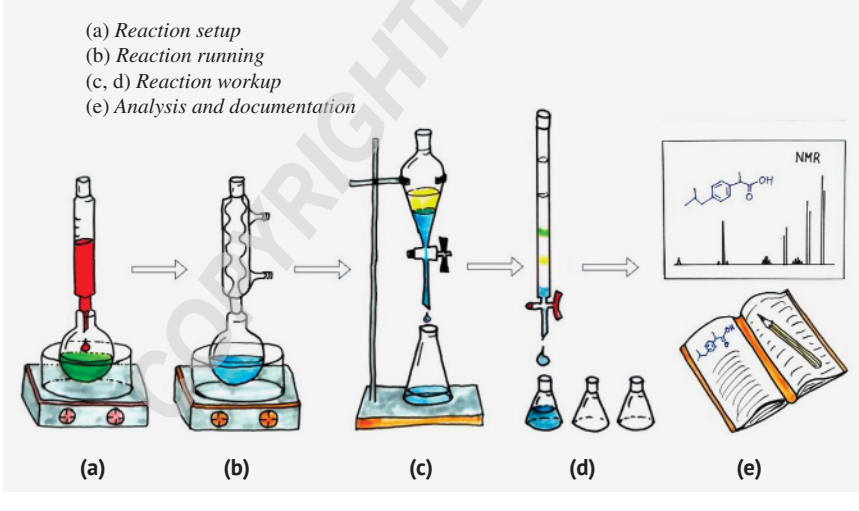

Figure 1.1 Typical workflow when you perform a synthetic step. Drawing courtesy of Elisabet Kallin.

At the molecular level, a reaction is when one or more bonds in a molecule are broken, and new bond(s) are formed, resulting in a new molecule. This could be

the molecule you want, but it could also be an intermediate molecule in a whole series of reactions ("synthetic steps") that end with your "target molecule." In the latter case, we are talking about a "multistep organic synthesis." We will return to this "molecule-assembly" activity in a later chapter, but first, some basics about performing a single synthetic step.

There are thousands of known organic reactions where the outcome can be reasonably well predicted when you know the starting chemicals and the conditions; many of them even have names like the Grignard reaction or the Wittig reaction. Every year, new reactions are discovered and described, further expanding the possibilities for organic chemists. Together, the enormous body of known "reactions" and their relationships make up much of the theoretical framework of organic chemistry.

However, when it comes to the laboratory practice ("preparative organic chemistry"), you will find that the equipment and procedures for carrying out the "reactions" are surprisingly few and rather simple, and, believe it or not, some have remained almost unchanged for a long time. Actually, much of the beauty of preparative organic chemistry is that it is possible to assemble, step by step, novel and very complex organic molecules using only a few simple procedures and relatively inexpensive equipment. This is in contrast to the situation today in many other branches of science, such as physics or astronomy, where expensive and complicated equipment are required to make any form of scientific progress. Of course, modern preparative organic chemistry has benefited enormously from the development of sophisticated analytical instruments (such as NMR and MS) that are now indispensable in any synthetic work. This text, however, centers around the basic organic chemistry lab procedures/tools and describes them in detail with emphasis on their simplicity. The aim is to help students and researchers to improve their skills in synthetic organic chemistry.

To put organic chemistry lab techniques in context, it helps to first take a look at how synthetic steps are described in experimental sections of scientific papers. Such texts are written with the assumption that the readers are organic chemists who are familiar with basic lab procedures, so these are simply referred to by "keywords" ("extracted," "flash column chromatography," etc.). A good example is the synthetic step shown in Figure 1.2, described in a paper from 2006 [1]. The experimental section for this step reads as follows (the keywords are highlighted in bold):

> *4-Iodo-7-oxo-6-aza-bicyclo[3.2.1]octane-6-carboxylic Acid tert-Butyl Ester (6).*
>
> Triethylamine (26.2 g, 120.2 mmol), N,N-dimethylaminopyridine (563 mg, 4.6 mmol) and di-tert-butyl dicarbonate (26.2 g, 120.2 mmol) were added sequentially to a solution of iodo lactam 5 (15.2 g, 60.5 mmol) in dichloromethane (100 mL) at 23 °C. The reaction mixture was **stirred** for 4 h and then saturated aqueous ammonium chloride (100 mL) was carefully added. The mixture was diluted with water (100 mL) and **extracted** with dichloromethane (3 × 200 mL). The combined extracts were **washed** with brine (100 mL), **dried** (magnesium sulfate) and **concentrated in vacuo**. The residue was purified by **flash column chromatography** (ethyl acetate:hexanes, 1:4) to afford iodo lactam 6 (20.9 g, 98%) as a colorless solid.

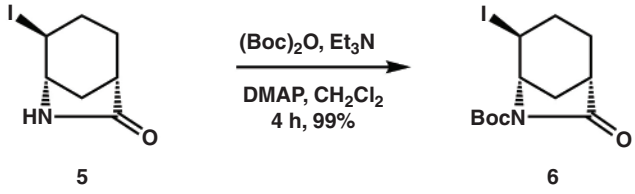

Figure 1.2 The N-acylation synthetic step. *Source*: [1] with permission of American Chemical Society.

Already in this short text, we can identify six "keywords." In the following chapters, we will describe the procedures behind the most common keywords and technical terms in enough detail that an average college student could easily understand them (see also "glossary of terms and keywords" at the end of this book).

When reading the text above, it is also important to note what is NOT mentioned, e.g., the reaction progress must have been monitored by some analytical technique (probably TLC), which is a normal routine. A chapter discussing different ways of "monitoring" reactions is included in this book (TLC, HPLC, MS, and NMR).

Even more importantly, the text does not mention anything about the risks associated with running that particular synthetic step. Lack of such information is common in the literature; the assumption is that whoever tries to carry out the described procedures should be familiar with the risks. This might not always be the case, so a chapter about the safety aspects of practical organic chemistry is also included in this book.

Reference

1 Yeung, Y., S. Hong, and E.J. Corey, A short enantioselective pathway for the synthesis of the anti-influenza neuraminidase inhibitor oseltamivir from 1,3-butadiene and acrylic acid. J Am Chem Soc, 2006. 128: pp. 6310–6311.