6 *Evaluating feedstocks and starting materials*

One of the greatest effects that the manufacture, processing, and use of a chemical substance has can be determined from its starting material. If the starting material, or feedstock from which the chemical product is made, has a negative environmental effect, it is very likely that the overall effect of the chemical substance itself will have a net negative effect. It is for this reason that evaluation of the feedstock or starting material is fundamental when conducting a green chemistry assessment of a chemical product or process.

The magnitude of the effect of the feedstock on the overall profile of the chemical product is dependent on a number of parameters, including the complexity and the length of the process that makes the chemical. If the preparation of the chemical is a one-step catalytic conversion to a petrochemical building block, then the environmental profile of the starting material is of paramount importance. If the end-product is a pharmaceutical that is manufactured via a 12-step synthetic pathway with complex processing and purification, the importance of the starting material may be somewhat diminished. In either of these cases, the profile of the starting material is the first step in evaluating the green chemistry of the chemical product or process.

6.1 Origins of the feedstock/starting materials

The first question is 'What is the origin of the feedstock/starting material in question?'. Is it mined, refined, synthesized, distilled, etc.? What are the consequences of the origins of the substance? A

chemical that originates from the use of an otherwise useless waste product that would need to be disposed of may very well have distinct environmental advantages to its use. A chemical that originates from a process that depletes a limited natural resource or results in irreversible environmental damage may have very negative effects on the environment. Both of these situations could be true regardless of whether the actual substance in question is harmful or innocuous. It is for this reason that one must first ask the question, how did this substance originate?

6.2 A renewable or a depleting resource

The information that derives from the question of what is the origin of the feedstock or starting material can be used to answer a second question in the green chemistry evaluation; 'Is the feedstock renewable or is it depleting a limited resource?'. One could argue that all substances are renewable given long enough time. For the purposes of a green chemistry evaluation, the distinction between depleting versus renewable should be placed in the context of a time frame of human experience, such as an average human lifespan rather than of geological time. As such, it is reasonable to consider that petroleum and other fossil fuel-based feedstocks are depleting and those feedstocks based on biomass and agricultural wastes are renewable.

It is possible that the same feedstock can come from a renewable or a depleting source, depending on its origin. In the case where carbon dioxide is used as a carbon-source building block, one could make the argument that if the CO2 were made from burning fossil fuels then it would be considered depleting whereas if it were generated from the combustion of biomass it might be considered renewable. In many cases, this argument is moot since the carbon dioxide is often generated from carbonate mineral deposits.

In the analysis of feedstocks, it would be preferable to have a sustainable supply, not only for current generations, but also for posterity. This factor of depleting resources is of concern not only for environmental reasons but for economic reasons as well, since a depleting resource will certainly increase the costs of manufacture and the price of purchase for the products being produced. Therefore, a renewable starting material would be preferable to

one that depletes the natural resources of the Earth, if all other factors are equal.

6.3 Hazardous or innocuous feedstock

An important question that will be at the heart of each step of a green chemistry evaluation is the consideration of intrinsic hazard to human health and the environment. A feedstock must be evaluated to determine whether it possesses chronic toxicity, carcinogenicity, ecotoxicity, etc. It is the feedstock that is going to have to be produced, often in large quantities, to manufacture a chemical product. It is the feedstock that is going to need to be handled by workers, again in large quantities, throughout the process. If this starting material does possess a significant hazard to human health and the environment, its effect will be felt throughout the life cycle of the chemical product.

6.4 Downstream implications of the choice of feedstock

The decision of what feedstock to use in the manufacture of a chemical product can and does have implications well beyond those directly attributable to the starting material itself. If the choice of feedstock will require that an extremely toxic substance is needed as a reagent to complete the transformation in the next step in the synthetic pathway, then it was the choice of feedstock that indirectly caused an even greater negative environmental impact than might be assumed on a first analysis. It could be true that an innocuous, renewable feedstock whose origins did not cause environmental damage, might still cause damage to human health and the environment because of the downstream substances that are requisite upon its utilization. It is therefore essential, as always when conducting a green chemistry analysis, not only to focus on the substances being analyzed at any particular part of the evaluation, but also to consider the implications and indirect consequences of using those materials.