The growth yield on more reduced substrate (hexadecane) is higher than that on partially oxidized substrate (glucose), assuming that two-thirds of all the entering carbon is incorporated in cellular structures. However, the oxygen yield on glucose is higher than that on the hexadecane, since glucose is partially oxidized.

7.4. THEORETICAL PREDICTIONS OF YIELD COEFFICIENTS

In aerobic fermentations, the growth yield per available electron in oxygen molecules is approximately 3.14 ± 0.11 gdw cells/electron when ammonia is used as the nitrogen source. The number of available electrons per oxygen molecule (O_2) is four. When the number of oxygen molecules per mole of substrate consumed is known, the growth yield coefficient, $Y_{X/S}$, can easily be calculated. Consider the aerobic catabolism of glucose.

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

The total number of available electrons in 1 mole of glucose is 24. The cellular yield per available electron is $Y_{X/S} = 24(3.14) = 76$ gdw cells/mol.

The predicted growth yield coefficient is $Y_{X/S} = 76/180 = 0.4$ gdw cells/g glucose. Most measured values of $Y_{X/S}$ for aerobic growth on glucose are 0.38 to 0.51 g/g (see Table 6.1).

The ATP yield ($Y_{X/ATP}$) in many anaerobic fermentations is approximately 10.5 ± 2 gdw cells/mol ATP. In aerobic fermentations, this yield varies between 6 and 29. When the energy yield of a metabolic pathway is known (N moles of ATP produced per gram of substrate consumed), the growth yield $Y_{X/S}$ can be calculated using the following equation:

$$Y_{X/S} = Y_{X/ATP}\,N$$

Example 7.2

Estimate the theoretical growth and product yield coefficients for ethanol fermentation by *S. cerevisiae* as described by the following overall reaction:

$$C_6H_{12}O_6 \longrightarrow 2\,C_2H_5OH + 2\,CO_2$$

Solution Since $Y_{X/ATP} \approx 10.5$ gdw/mol ATP and since glycolysis yields 2 ATP/mol of glucose in yeast,

$$Y_{X/S} \approx 10.5 \text{ gdw/mol ATP} \cdot 2\frac{\text{moles ATP}}{180 \text{ g glucose}}$$

or

$$Y_{X/S} \approx 0.117 \text{ gdw/g glucose}$$

For complete conversion of glucose to ethanol by the yeast pathway, the maximal yield would be

$$Y_{P/S} = \frac{2(46)}{180} = 0.51 \text{ g ethanol/g glucose}$$