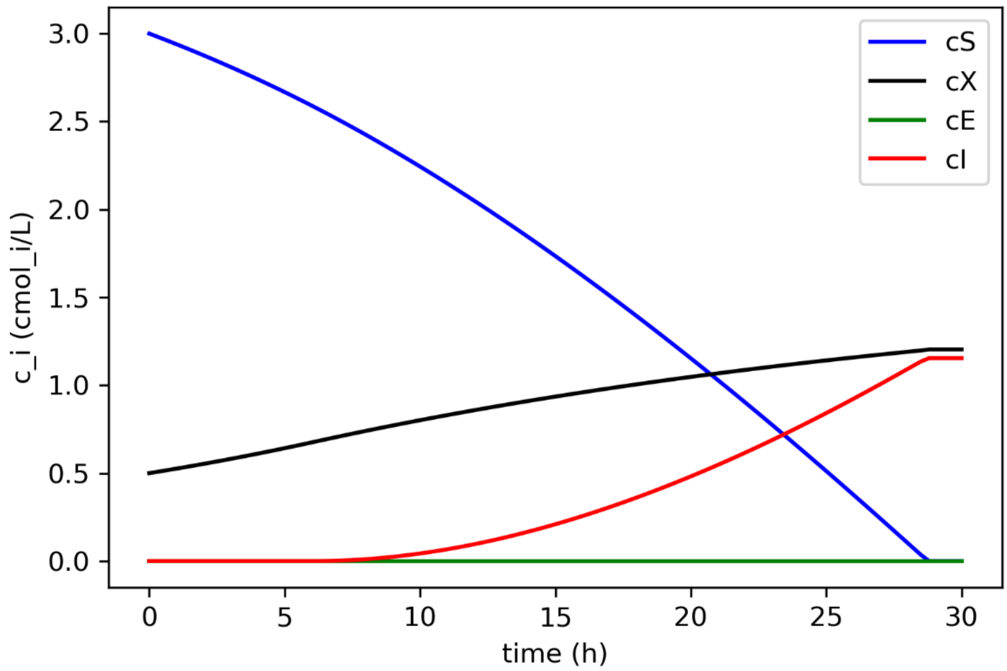
CBP 732: Assignment 2

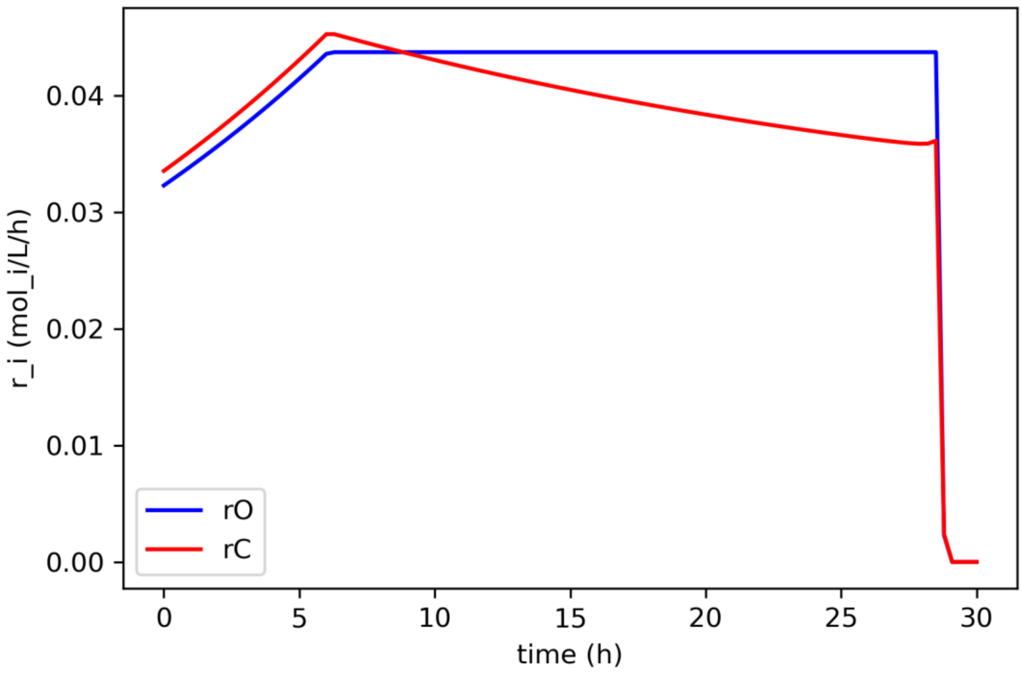
Part 1

Conditions:

Alpha	0.1	Mol_CO2/cmol_X
Gamma	2.5	Mol_ATP/cmol_X
Mu_max	0.05	1/h
Theta_max	0.1	Mol_ATP/cmol_X/h
P/O	1.5	Mol_ATP/mol_O
Km	0.001	Cmol_S/L
K_La	200	1/h
C_O2_sat_max	7	Mg/L
C_S_0	3	Cmol/L
C_X_0	0.5	Cmol/L

Results:





Diano et. al. 2006:

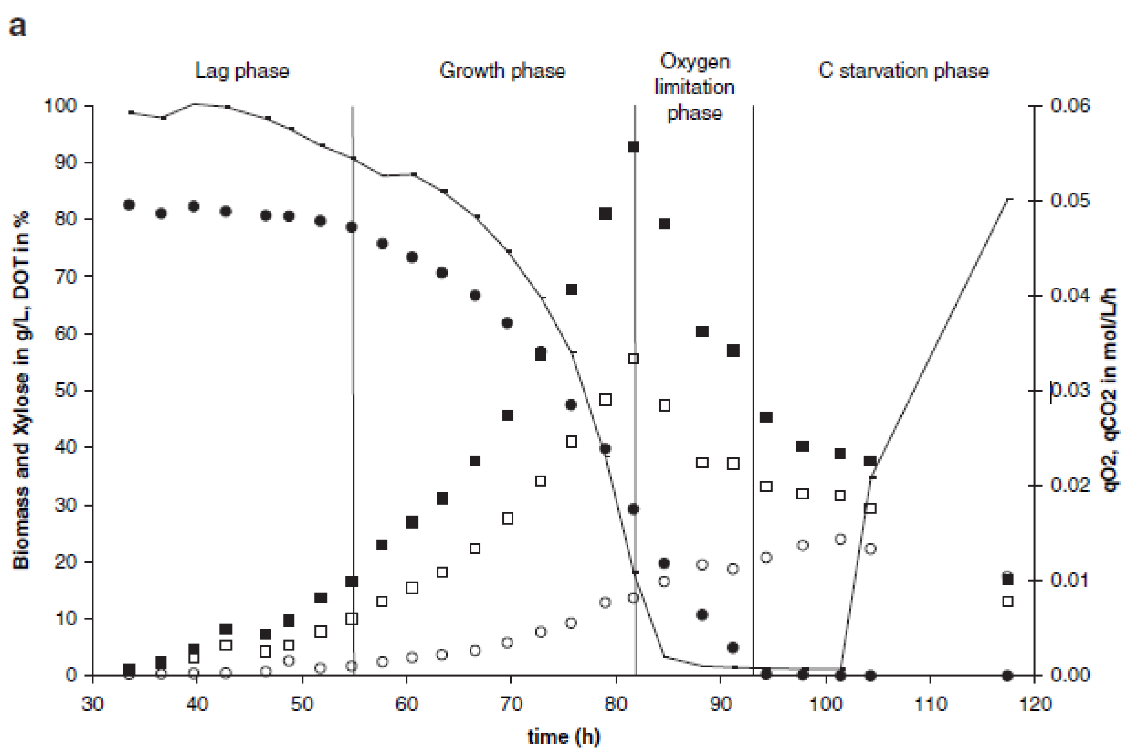


Figure 2. Profile of the fermentation using xylose as carbon source and nitrate as nitrogen source. **a**: Biomass (○), xylose (●), DOT (–), qO_2 (□), and qCO_2 (■). **b**: DOT (–), mannitol (▲), erythritol(△), glycerol (◆) arabitol (◇), and xylitol (+). **c**: DOT (–), pyruvate (◆), citrate (—), and succinate(✦).

Model corresponds to data, except for O2 flux. Why?

Part 2

Diano et. al. 2006:

An increased hyphae concentration causes an increased medium viscosity and thus reduces oxygen mass transfer capabilities as well as general mass transfer of components. This could cause a switch between fully aerobic and oxygen limited conditions.

Three important phases: lag phase, growth phase and oxygen limited phase as seen in graph above. This is why there is a difference between the theoretical and actual values for oxygen consumption. Theoretically the slope of r_{O2} should plateau after the maximum acceptable soluble O_2 limit is reached. Because the medium viscosity increases, the k_La value effectively decreases as biomass increases. This accounts for the difference between theoretical and actual results.

As medium viscosity increases, the glucose consumption rate also decreases. The study shows that $Y_{S,CO2}$ increases although r_{CO2} decreases. $Y_{S,X}$ decreases, $Y_{S,SA}$ increases. $Y_{S,CO2}$ probably increases due to the catabolism shifting to the PP pathway.

Meijer et. al. 2007

It was found that the biomass concentration increases with aeration and by-product formation increases at lower aeration.

TCA cycle catabolites accumulate during oxygen limitation.

The PP pathway is more active.

Diano et. al. 2009

Oxygen limitation was investigated by changing the % O_2 of incoming airflow, thereby, changing the effective k_La.

Carbon limitation: When only a carbon source limitation is applicable, the cell's focus is mainly on producing biomass with very few catabolites.

Oxygen limitation: Low O_2 concentrations mean low final electron acceptor concentrations in the electron transfer chain. This causes low NADH consumption and, therefore, low ATP production. This imbalance between the ATP required and available causes the anabolism and catabolism to uncouple and increases the catabolic production.

Citric acid is produced via the TCA cycle in the mitochondria, while malate and fumerate is produced in the mitochondria as well as the cytosol via oxaloacetate (which possibly increases fumerate respiration capability?).

The intercellular pH decreases due to not enough ATPs being generated. This low pH causes a decrease in NADP+ isocitrate dehydrogenase activity. This increases the citric acid production rate. The excess citric acid is then excreted by the cell, thus reducing intercellular pH and restoring cell homeostasis and optimal cell pH. Other acids could possibly substitute for citrate in this function (like itaconic acid?).

The effect of oxygen availability on citrate production differs between biomass morphologies (free hyphae or pellets).

pH reduction also decreases hexokinase and 6-phosphofructoskinase activity. This results in a decrease of the Embden-Meyerhof-Parnas (EMP) pathway activity, which explains the decrease in r_S when oxygen availability decreases.

The reduced r_CO2 is due to the TCA of PP pathways being inhibited.

O2 limitation does not influence the morphology in *A. niger*, but might in *A. oryzae* or others.