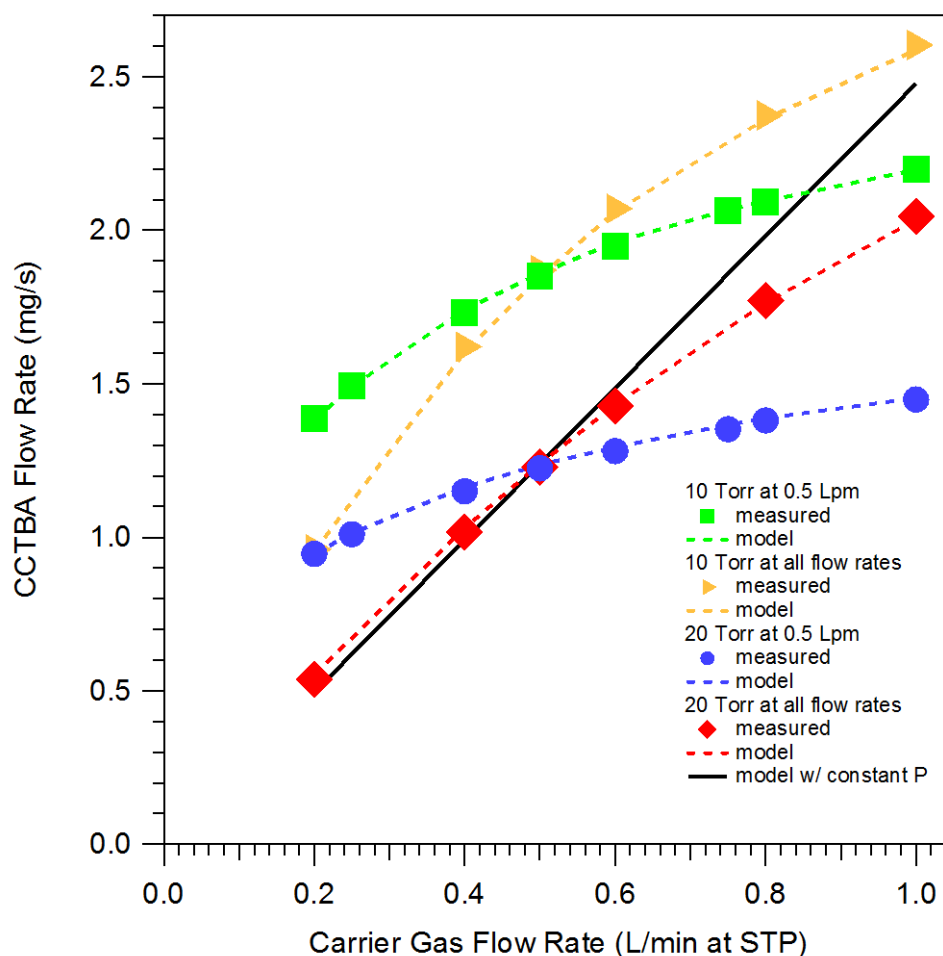


Modeling ampoule performance for low vapor pressure precursor delivery



The symbols in the figure show the measured CCTBA flow rate from a bubbler as a function of carrier gas flow rate. Under these delivery conditions, the relationship between the CCTBA and carrier gas flow rate is non-linear. The dashed lines show the calculated CCTBA flow rate obtained using an analytical model that accounts for the pressure drop between the ampoule head space and the downstream pressure control point. The different traces represent different pressure control conditions. For all calculations, the CCTBA partial pressure in the bubbler headspace was taken to be 0.22 Torr. The model results are in good agreement with the measured data for these conditions. The solid line shows the calculated CCTBA flow rate obtained using the model and assuming a constant total pressure in the bubbler headspace (a condition that can be difficult to achieve in practice). In this case, the relationship between the CCTBA and carrier gas flow rate is linear. This is the expected form of the relationship for systems operated with a very low pressure drop between the ampoule headspace and the pressure control point, e.g., at high total system pressure.