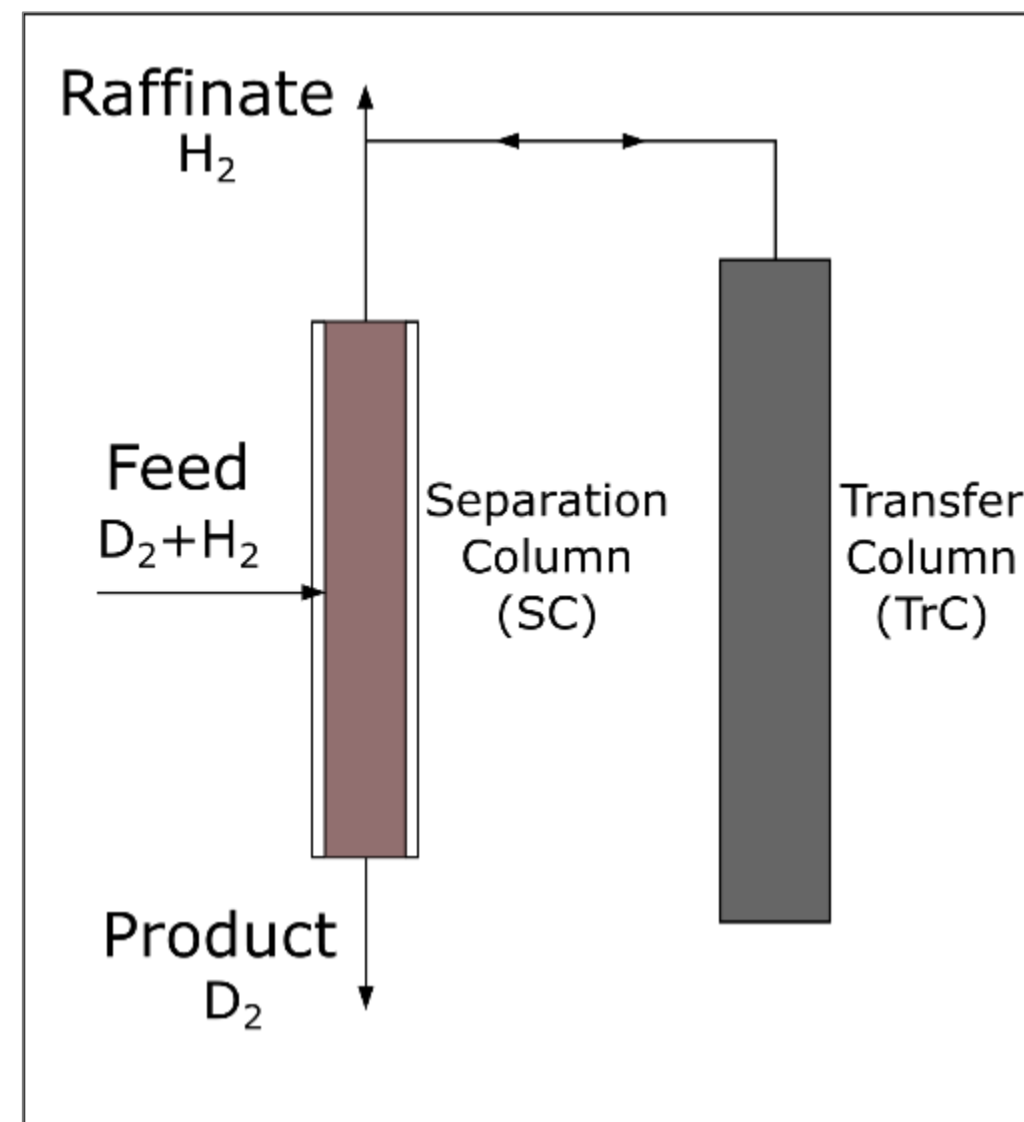


Thermal Cycling Absorption Process (TCAP) for Hydrogen Isotope Separation

Hugh Boniface - Technical Lead; Adrián Vega - Task Holder

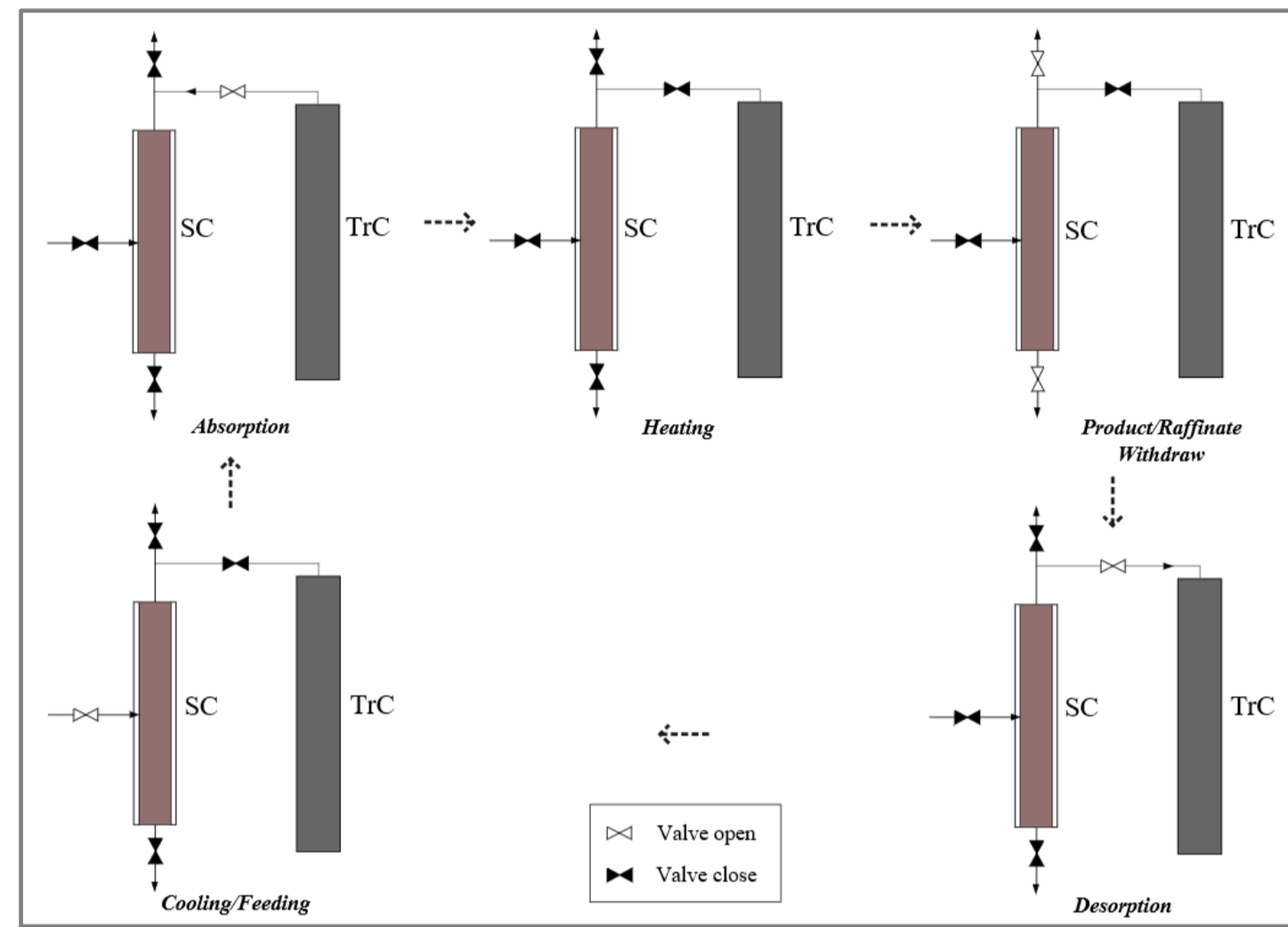
Background

TCAP is a displacement chromatography separation technology that can be used to **separate hydrogen isotopes**.



TCAP System Schematic

- The temperature of the SC is cycled in concert with input and output flows between the SC and TrC.
- Throughput mode – A gas mixture is fed and Raffinate and Product are withdrawn in every cycle.



Rationale

- Importance of tritium control in nuclear reactors.
- Complexity & cost of current back-end detritiation processes.
- Deuterium and Tritium supply for Fusion Reactors.
- Current preparation drawbacks of TCAP absorbent material.

Objectives

- Demonstrate successful operation of a high-pressure TCAP system as the basis for a design for a tritium removal system.
- Further develop/test TCAP absorbent materials.

Federal Stakeholder — NRCAN

Project Status and Progress

Absorbent Development/Production

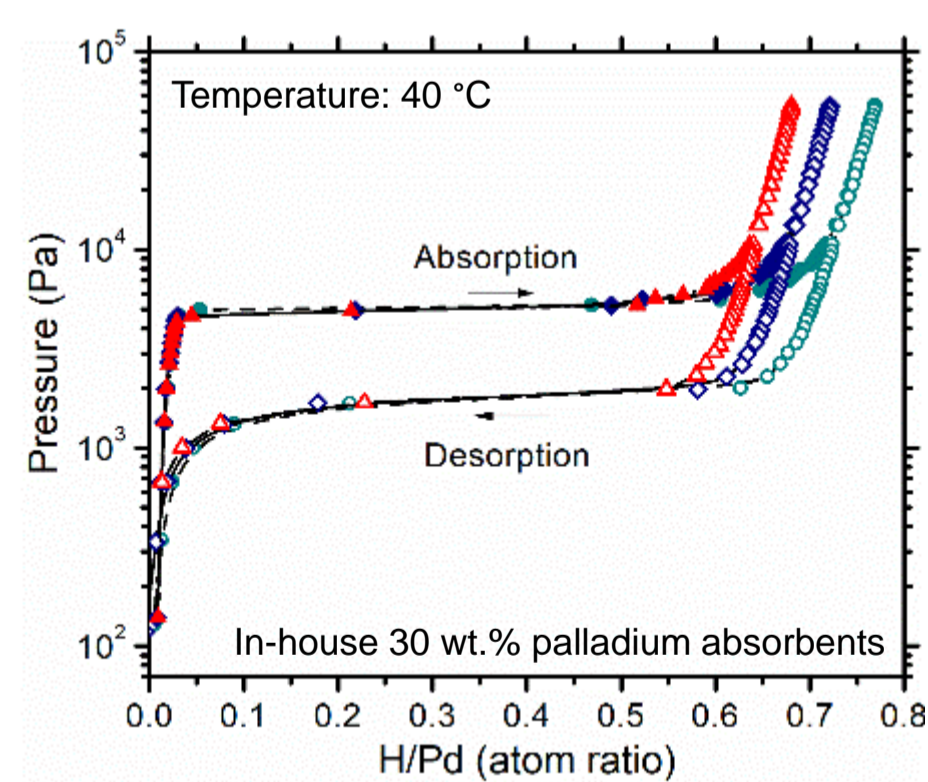
- Developed and characterized palladium-based absorbents by *Precipitation Method*.



Palladium precursor

Absorbent – 30 wt.% palladium on silica

- Completed production and characterization of ca. 600 g of palladium-based absorbent to be used in the high-pressure experimental system.



Isotherms confirmed high capacity for hydrogen absorption

- Continue with the development of alternative/novel palladium-based absorbents:

- Different supports with better thermal conductivity than silica.
- Different palladium loadings.

Process Development

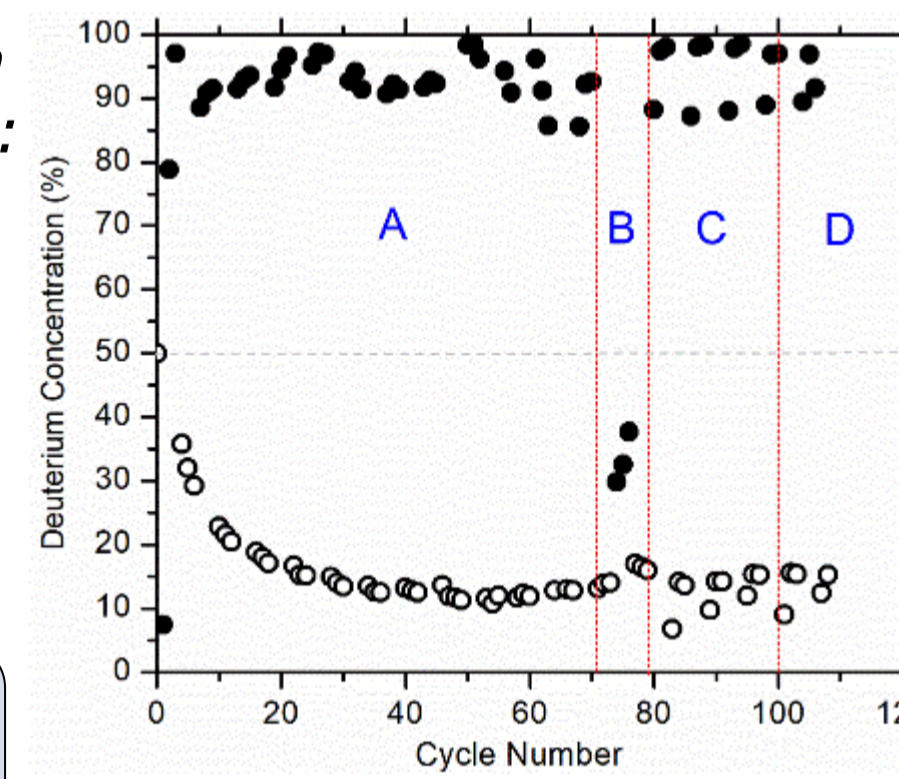
- Design, construction, commissioning and testing of a semi-automated low-pressure TCAP system for non-tritium separations (Max. pressure of 200 kPa – abs.).



Throughput of the system (volume of gas per cycle):

- 50 mL (Section A & C)
- 75 mL (Section B)
- 60 mL (Section D)

The current system has the ability to separate ca. **60 mL of gas per cycle**.



Conditions: Feed: 50/50 vol% D₂/H₂ 30 wt% Pd-based absorbent; pressure: ca. 200 kPa - abs.

- Certified design for a high-pressure TCAP system for non-tritium separations (Max. pressure of 1400 kPa – abs.).

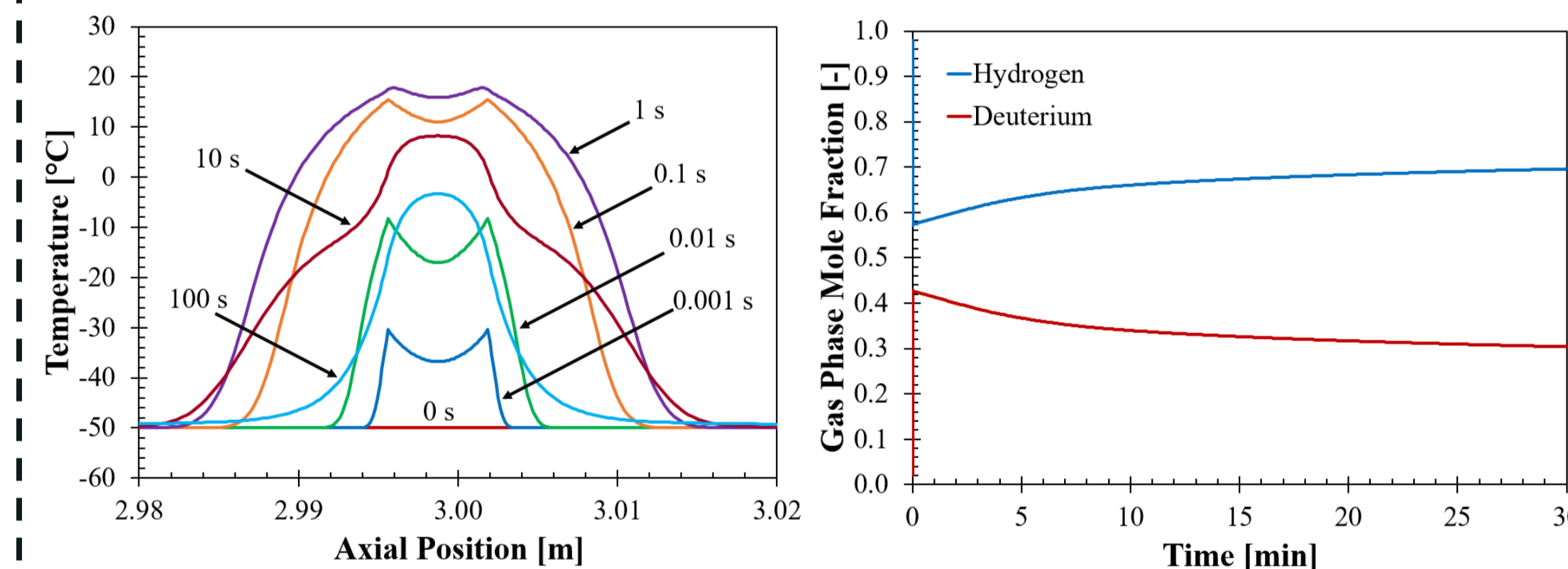


- Construction of the high-pressure TCAP system (non-tritium mixtures) started:
 - To be completed by October, 2019.

Process Modeling

- Development of a fundamental process model for the TCAP separation system (work still in progress):

- Model developed in Fortran.
- Focus on the transport phenomena within the SC (i.e., the TrC has not been modeled yet).



Temperature profile in the vicinity of the injection point in the SC

Average concentration in the SC

Outcomes (March 2021)

An effective tritium separation process with potential to replace cryogenic distillation

- A functional high-pressure system for non-tritium separations (i.e., hydrogen and deuterium mixtures).
- A conceptual design for a high-pressure system for tritium separations (e.g., tritium and deuterium mixtures).
- A fundamental understanding of the dynamics of the separation through numerical modeling.
 - Aim to improve operation and future designs of the TCAP process.

