Technology Readiness Level: 2
Technology Concept and/or Application Formulated

Eltron Research & Development

Tech Brief

# Selective and Rapid Alcohols/Hydrocarbons Synthesis In Moderate Conditions

**Advantages**

- Can achieve CO reduction to alcohols and hydrocarbons at 98% Faradaic efficiency.
- **Three orders of magnitude faster and higher productivity**, than thermochemical alcohols synthesis.
- Can vary cathode voltage to obtain different products, control reaction selectivity. When hydrogen is fed to the cathode side of the electrolyzer, reaction is downhill.
- Can use hydrogen from gasification to produce electrical energy for electrochemistry.
- Close-to-ambient operating conditions.
- **Simple:** Thermal runaway, control systems complexity and problems reduced.
- Electrical pulses can be used to reactivate electrodes. No catalyst sintering.
- Potentially higher efficiency than thermal combined cycles.
- Eltron's gasification step alone, lowers capital costs 20-25%

Eltron has developed a ***selective*** electrochemical process for reducing CO, $CO_2$, or syngas to either hydrocarbons or alcohols which, when combined with gasification, gives a carbon source-to-fuel technology.

Demonstrated at the bench-scale, Eltron's process is particularly promising for mobile and distributed fuel synthesis, where biomass and waste are likely feeds. Ultimately, the technology can lower costs by reducing the number of unit operations, as well as equipment size and weight. Eltron's gasification step alone, lowers capital costs by 20-25% from current systems. The process also is capable of reducing the need for product upgrading.

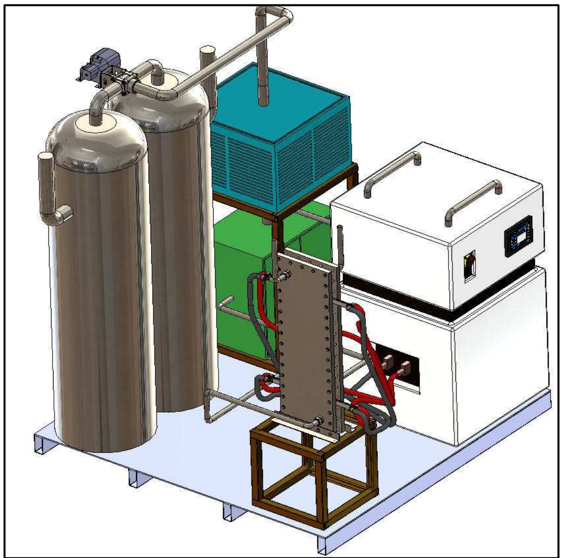

***Figure 1.***
*Conceptual rendering of Eltron's system for conversion of biomass to alcohols.*

The proprietary electrochemical CO conversion process can supply alcohols at rate and productivity up to three orders of magnitude greater than thermochemical methods. Furthermore, Eltron's process operates under less severe conditions and is much simpler, requiring less capital investment and less demanding plant design than conventional alcohol synthesis processes.

The overall process is less complex than other combined cycle systems (**Figure 1**). It integrates gasification and electrochemical reduction (**Figure 2**), and is of comparable complexity to thermocatalytic alcohol synthesis processes. A thermocatalytic system would contain the same or a greater number of such modules (gasifier, compressor, gas clean-up, water-gas shift, reactor, and separations), plus utilities such as natural gas for heating purposes, etc.

Eltron's approach offers advantages over microbial-based processes. It is capable of much more rapid fuel production (e.g., ethanol) using much smaller reactors, without the separation issues associated with fermentative processes. For example, ethylene can be produced at up to 98% selectivity and can be oligomerized to diesel or JP-8, or hydrated to ethanol.

When hydrogen is fed to the anode side, a strongly exothermic process results. A downstream $H_2$/air fuel cell would supply electric power. The overall process can then be net energy producing or at the least produce sufficient energy to run the CO electrolysis.

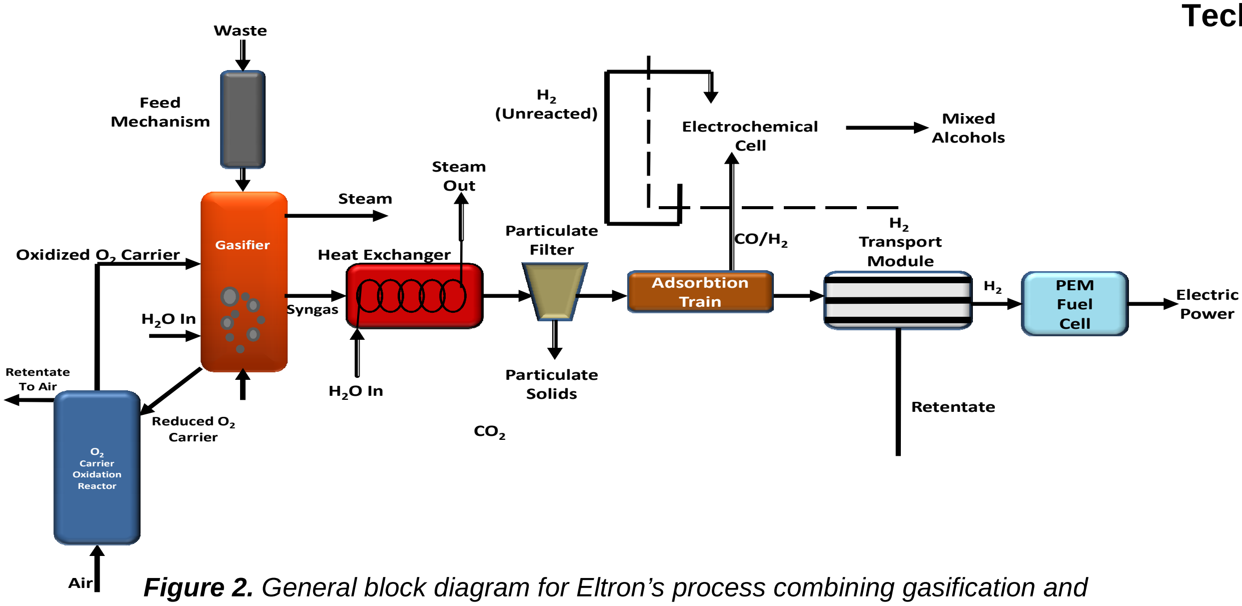


***Figure 2.*** *General block diagram for Eltron's process combining gasification and electrochemical syngas reduction/oliglomerization.*

The process utilizes either aqueous carbonate solutions and gas diffusion electrodes in a divided electrochemical cell or gaseous feed with membrane-electrode assembly (MEA) based electrolytic cells. Although the cathode reactions are highly endothermic and require energy input, ***one strategy for reducing the thermodynamic penalty is to depolarize the anode using hydrogen from syngas produced in gasification. This imparts considerable exothermicity to the process, with the overall cell reaction and thermodynamics being entirely analogous to thermal routes (overall stoichiometry:***

$$2CO+4H_2 \rightarrow C_2H_5OH+H_2O;\quad \Delta H_r = -81.84\,{}^{kcal}/_{mole},\quad \Delta G_r = -32.84\,{}^{kcal}/_{mole},\quad \text{and}\quad E = +0.178V).$$

In fact, one possible route to the use of hydrogen at the anode is to pass CO-depleted syngas over the anode, potentially eliminating the need for an hydrogen transport membrane (HTM).

The cathode reactions are electrocatalyzed by metal alloys or other materials and the product distribution is controlled by the cathode electrocatalyst employed: Some materials favor hydrocarbons, others, alcohols. In any event, Faradaic efficiency of up to 98% to alcohol and hydrocarbon products have been obtained at a current density of 600 $mA/cm^2$ when CO is employed. Synthesis gas may be directly fed to the cathode, since $H_2$ will not be directly reduced. Eltron has developed new materials for the process that are potentially much more productive than those previously identified; they have much higher surface areas, greater dispersion, and more intense surface electric field gradients can be obtained.

## Stage of Development

Eltron has developed the CO conversion process, and further testing is needed.

The technologies described, and all related inventions are owned by Eltron Research & Development Inc, and protected by copyrights, trademarks, issued and pending patents, trade secrets, or other applicable intellectual property rights.

### Contact Us

To discuss the possibility of entering into a business relationship with Eltron, contact the Business Development Group at: business@eltronresearch.com.

Eltron Research & Development

**Eltron Research & Development Inc.**

Eltron Research & Development commercializes novel technologies involving energy, chemicals, advanced materials and environmental systems.

4600 Nautilus Court South | Boulder, CO 80301 | Phone: 303.530.0263 | www.eltronresearch.com