



E-TEK

New Catalysts and Low Cost ELAT® Materials for Fuel Cell Applications

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with

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DE NORA ELETTRODI NETWORK
GRUPPO DE NORA

Introduction

- **Catalysts**
- **Gas Diffusion Layers and Electrodes**
- **New MEA**
- **Success story of first MEA commercialization**

In 2001 began intensive program for creating new catalyst products

- **Approach**

- *Create more active catalyst face (pure Pt) or phase (alloy) through structure-activity relationship: increase utilization of platinum*
- *“Re-invent our process chemistry from the beginning”*

- **Goal:** High surface area, high electrochemical activity

- **Cost Objective:** Inexpensive chemistry with lower environmental impact

- **Results**

- *More uniform catalyst distribution from new colloidal Pt chemistry*
- *Better crystallite size control especially at high loading*

New High Performance Platinum Catalysts

Comparison Crystallite Size (XRD, nm) on Vulcan XC-72

<u>%Pt/C</u>	<u>Std</u>	<u>HP</u>
10	2.0	-
20	2.5	2.2
30	3.2	2.5
40	3.9	2.8
60	8.8	3.7
80	25	4.9

- New chemistry/ reduced sulfur levels – no Cl⁻
- Achieved lower processing costs
- Single large batches available 1 Kg batch

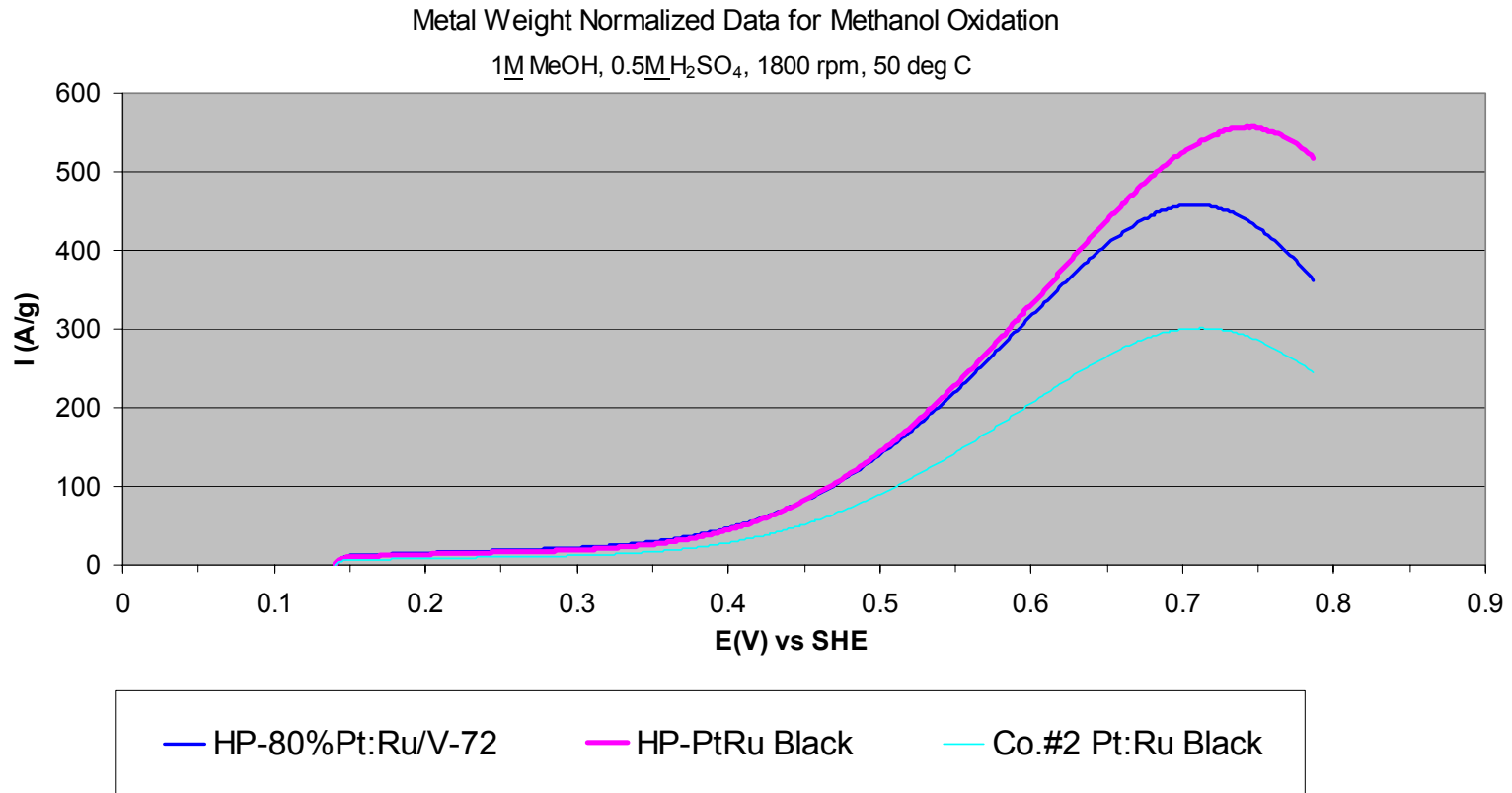
Comparison ECSA (CO stripping, m²/g)

<u>%Pt/C</u>	<u>Std</u>	<u>HP</u>
30	32	53
40	-	39
60	-	28

Comparison of % electroactive for 30% Pt/C

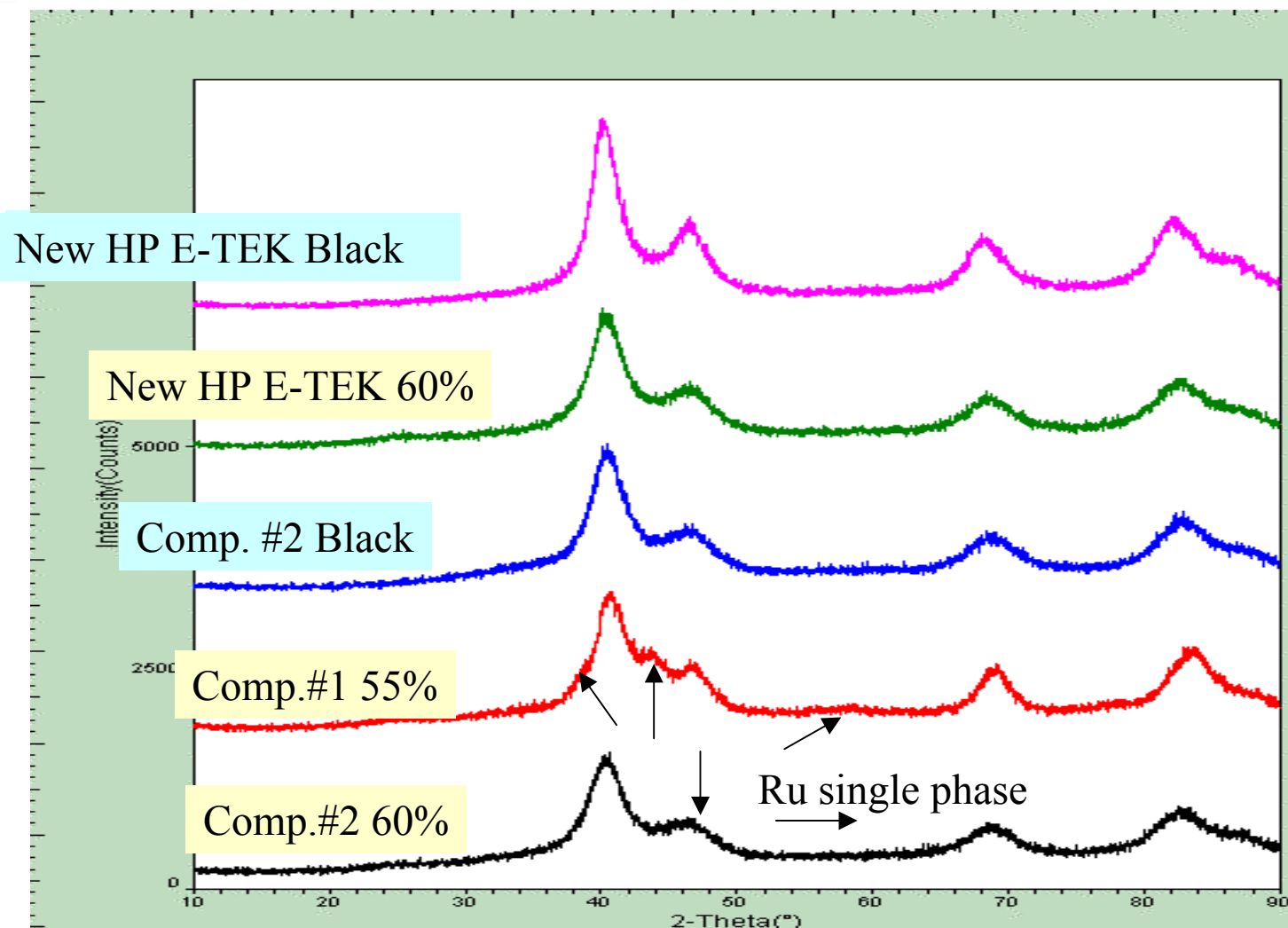
<u>Catalyst</u>	<u>tot Pt S.A.</u>	<u>%electroactive</u>
Standard	88 m ² /g	36
HP	112 m ² /g	47

HP Pt:Ru_{black} as an alternative to [Pt:Ru] oxides



- Higher degree of alloying and purity compared to [Pt:Ru] oxides
- HP 80% Pt:Ru on Vulcan XC-72 offers improved processing for inks

XRD Spectra of 60% Supported and Unsupported PtRu (1:1 a/o) Catalysts



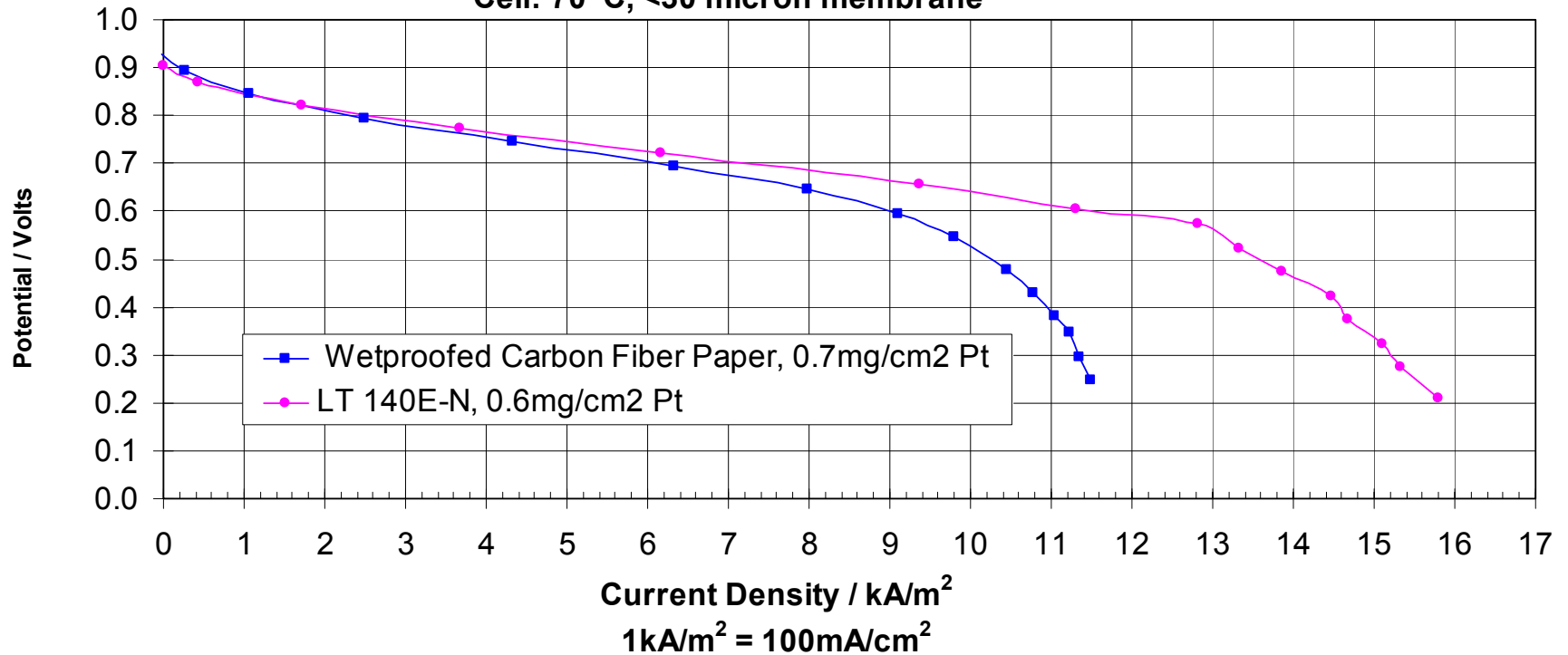
The higher degree of alloying with new process follows with lower total metal loadings on carbon (i.e., 20-40% Pt:Ru)

Next Generation of ELAT® Products

- **What is an ELAT?**
 - **Three dimensional microporous layer constructed around a web material such as carbon cloth or paper**
 - **When the microporous layer contains a catalyst, this is called a gas diffusion electrode**
- **First introduced as a hand fabricated assembly in the mid 1980's, and re-invented as a machine fabricated rolled good in 1999**
- **Initially offered only four limited machine product platforms, but now have a full diversity of products for a multitude of applications and operating conditions**

ELAT on non-woven (carbon paper)

Cathode/Anode: 1.5 Bar A, 70°C; H₂/Air 1.5/2 stoich
Cell: 70°C, <30 micron membrane



ELAT microporous layer improves transport

Third Generation Materials for use under 95 °C

- **New Carbon Paper based product**
 - LT 1100-N
 - Others being developed
- **Low cost standard GDL or GDE**
 - LT 1400-W / LT 140E-W
- **Operation under highly flooding conditions, or need sealing against bipolar plate lans**
 - LT 2500-W / LT 250E-W
- **Anode for Reformate**
 - LT 140T-W or LT 250T-W
- **Portable or applications needing thin GDL**
 - LT 1200-W

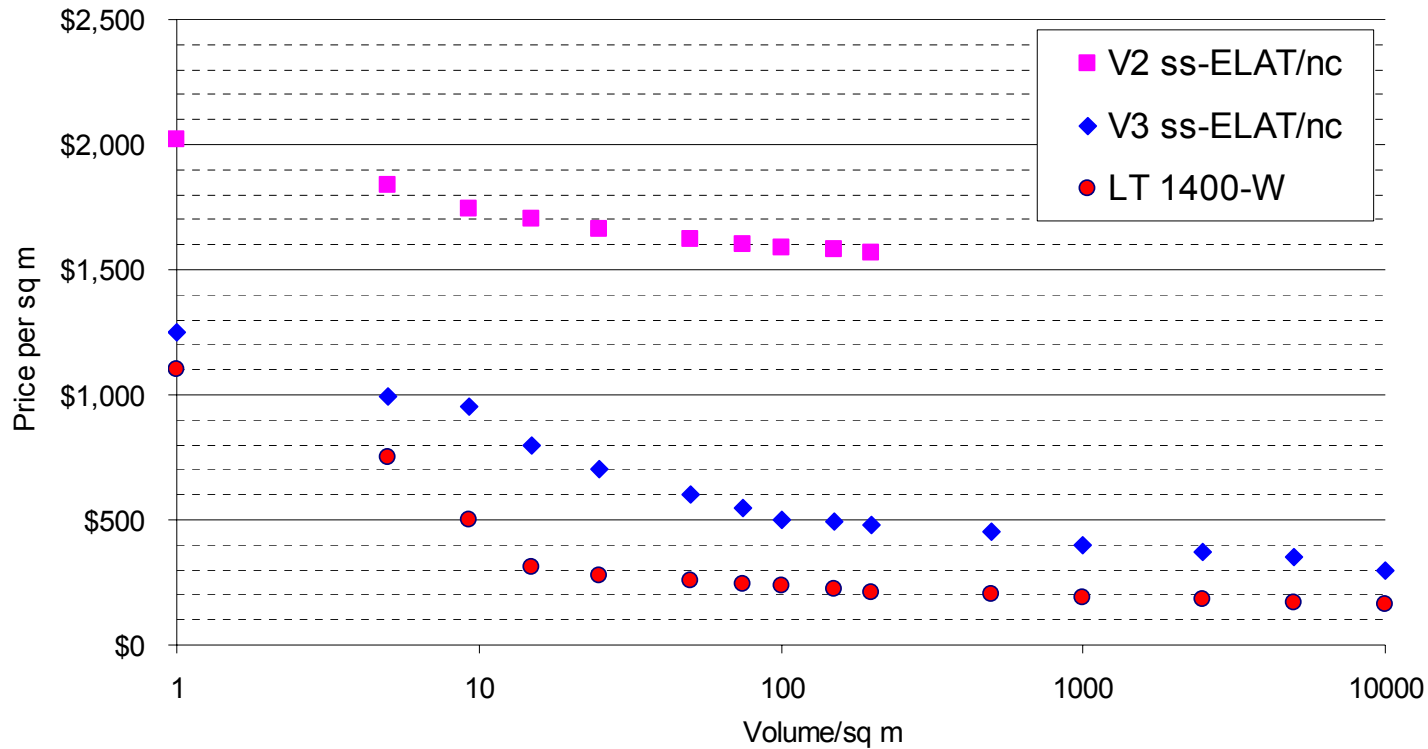
Best Combination
of value and
performance

First release of materials designed for high temperature operation

Products for over 95 deg C where water is vapor

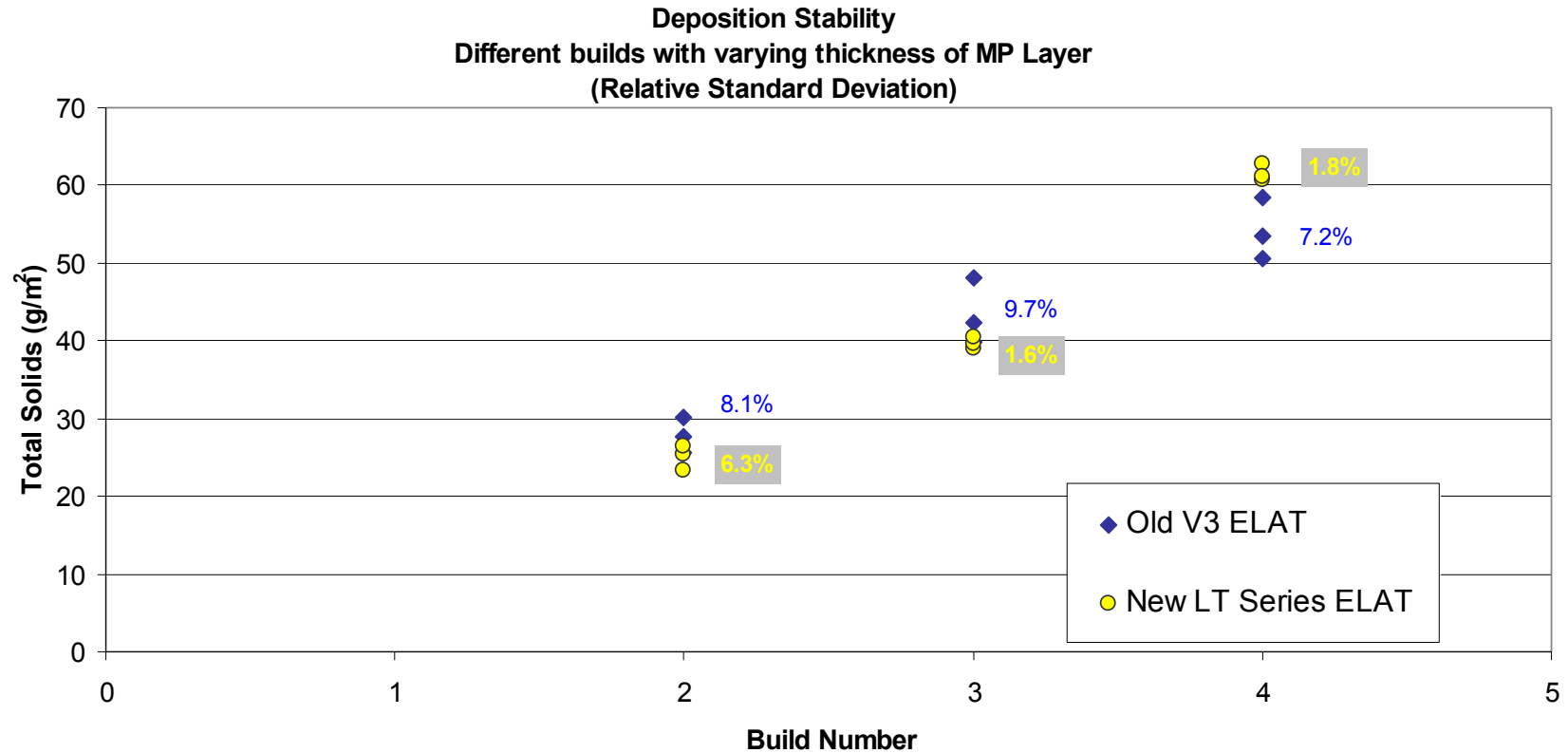
- **Standard GDE for developing new HT Membranes**
 - HT 140E-W or HT 250E-W
- **Standard GDL for catalyzed HT Membranes**
 - HT 1400-W or HT 2500-W

The new generation machine ELAT is available at lower costs: LT 1400-W



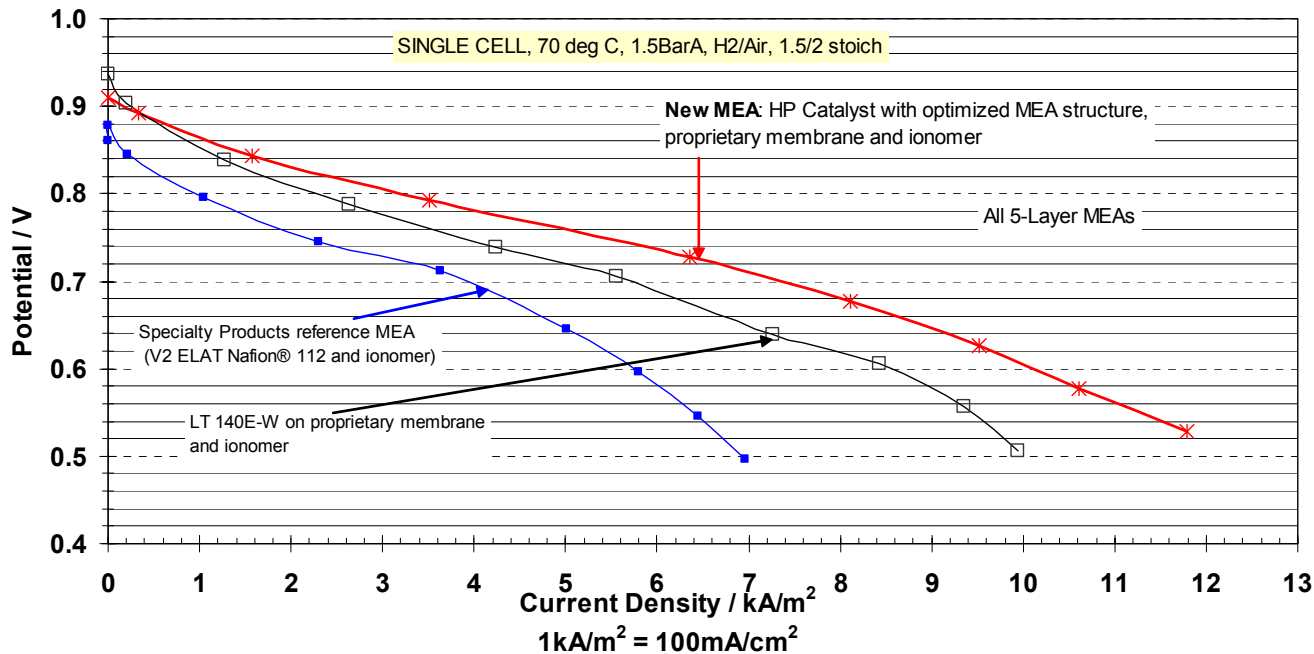
Have reduced price by ~ an order of magnitude in less than four years

New generation machine ELAT: improved consistency



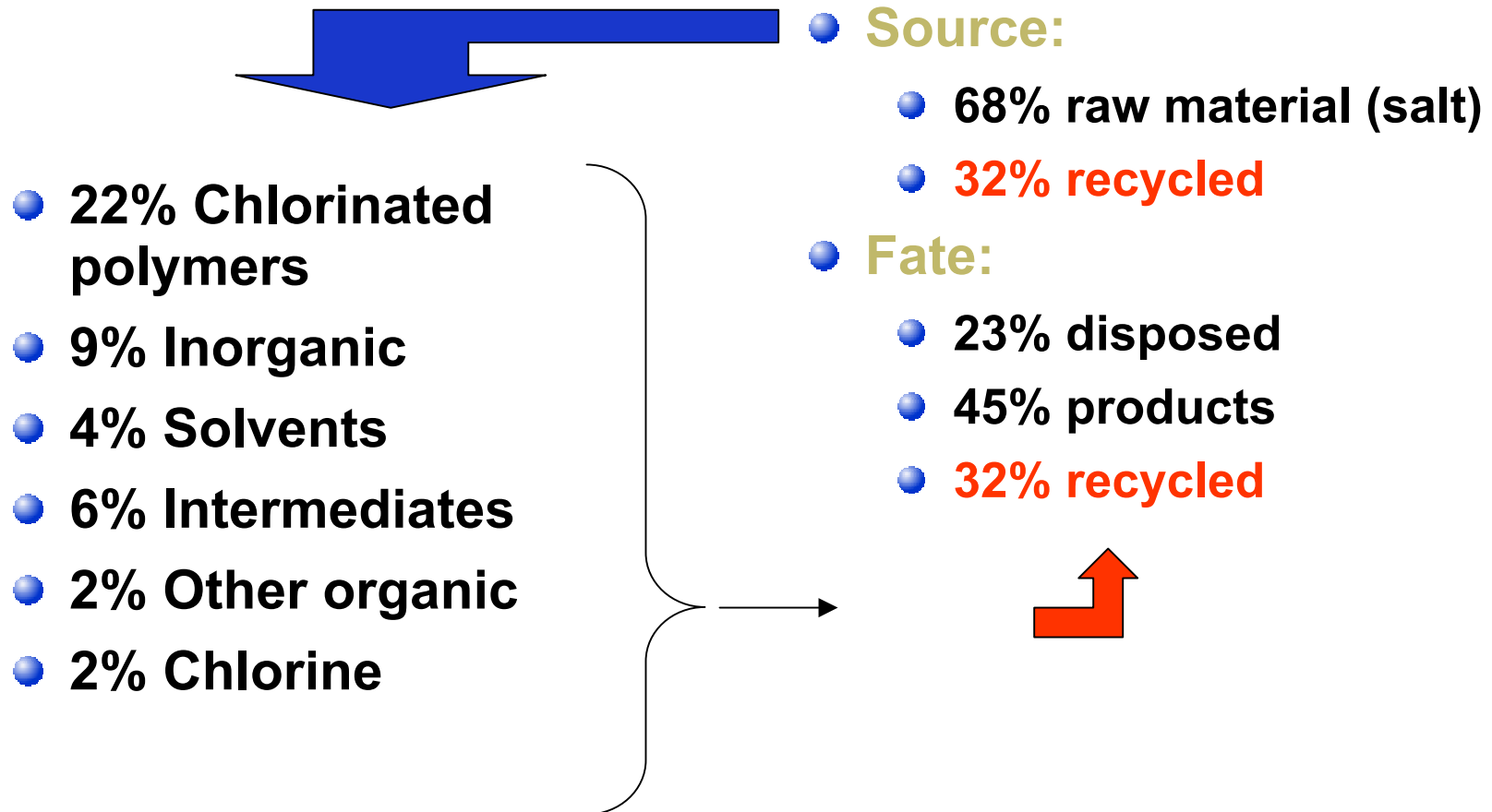
New Commercial 5-layer MEA

E-TEK Series 14 MEA



- Based on new HP Catalyst
- New matched ELAT® structure
- Proprietary Membrane and ionomer
- Highly flexible manufacturing system: delivered pre-punched to customer's specification

First market for fuel cell materials: chemical process industry – De Nora's chlorine recovery

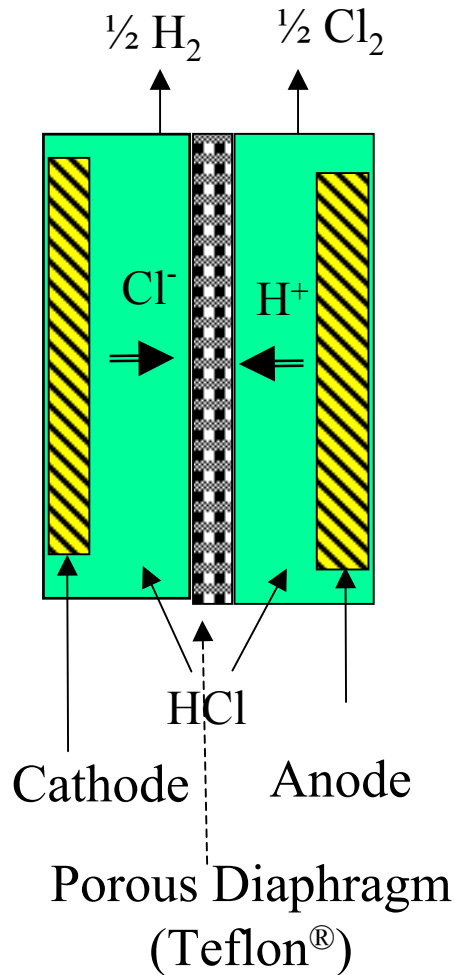


European Chlorine Market: 14.2 million tons/yr.

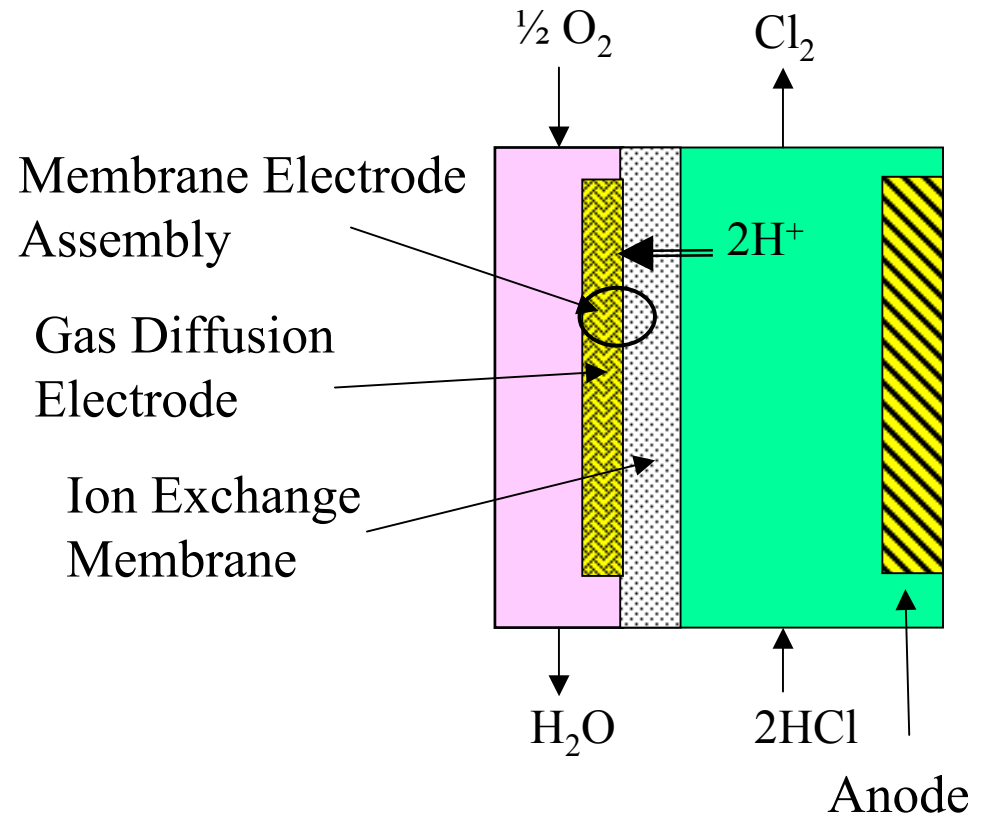
*From: C&EN, March 17, 1997, p.17

Electrochemical recovery of chlorine: driven process (apply current)

Traditional Process: 2.2-2.4V



$\frac{1}{2}$ MEA: <1.5V



Demonstration Plant Results (70 elements~180 sq m)

- Validated materials of construction
- Demonstrated process scale-up and qualified manufacturing procedures for catalyst, ELAT, MEA, and electrolyzer stack
- Established:
 - energy saving: 500 kWh/tCl₂
 - quality of Cl₂: < 0.1% O₂
 - current efficiency: ~100 %
- *First Commercial Plant in operation (October '03 – Brunsbuettel, Germany)*



Conclusions

- **New HP catalyst products provide higher power to fuel cell assemblies**
- **Improved and highly diversified next generation of machine made ELAT products**
- **Introduction of a MEA designed from the interface and optimized through matched ELAT structures**
- **Established first commercial market: application of fuel cell materials to electrochemical process industry**

Acknowledgements

- **DOE Cooperative Agreement DE-FC04-02AL67606**
 - **Industrie De Nora companies such as De Nora Technologie Elettrochimiche and Uhdenora S.p.A.**
 - **Bayer Technology AG**
 - **technical staff at E-TEK division**
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