Application Note

HAMILTON

Real-time Yeast Health Monitoring in Industrial Ethanol Plants with In-Line Permittivity

Industry: Precision Fermentation / Bioeconomy Fermentation

Application field: VCD Monitoring and Viability Estimation

Hamilton products: Incyte Arc

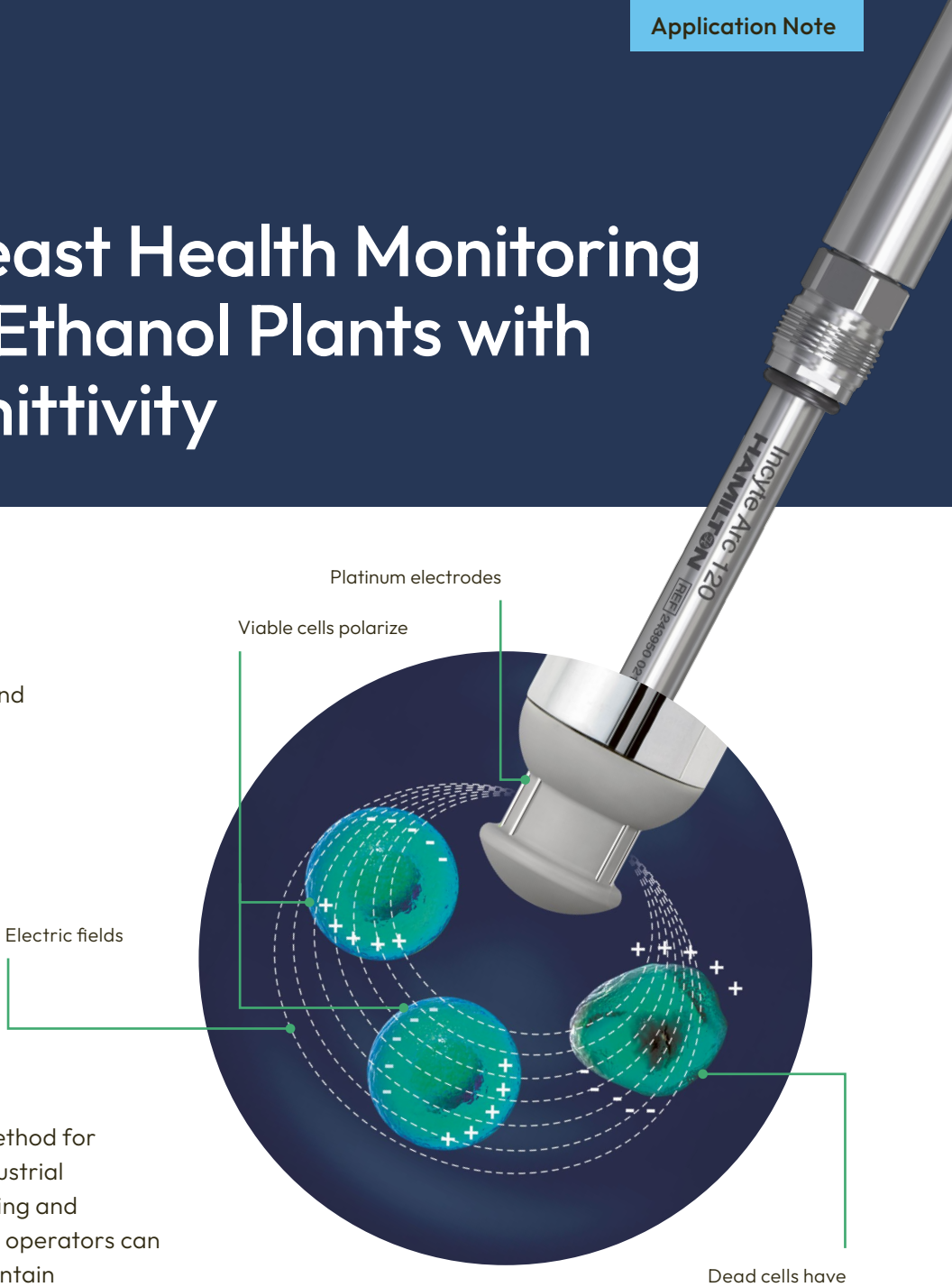

Figure 1: Incyte Arc polarizes only living cells.

In-line sensors offer an effective method for improving ethanol production in industrial fermentation processes. By measuring and controlling viable cell density (VCD), operators can make real-time interventions to maintain optimal conditions. Continuous VCD monitoring enables process engineers to both track culture performance and optimize fermentation efficiency.

Permittivity sensors, such as Hamilton Company's Incyte Arc, measure VCD by generating an electric field within the fermentation medium. Viable cells within this field become polarized as intracellular charged particles shift in response (Figure 1). In principle, this polarization increases proportionally with viable biomass, and thus can be directly correlated against reference samples, enabling real-time assessment of VCD.

Cargill, Inc. used an Incyte Arc sensor in their pilot-scale ethanol fermentation process to monitor yeast viable cell density (VCD). Live yeast was stained and counted using a cellometer and the results were compared to the VCD probe readings. Multiple trials were conducted observing different stages of fermentation. After 26 hours, the tank was heated to 41°C.

The Incyte Arc correlated tightly with off-line cellometer counts during the log phase of growth (Figure 2A and B). The correlation strength allowed for a simple single factor slope to be applied to the Incyte Arc permittivity to predict cellometer-equivalent cell counts continuously in-process. Future runs will utilize the established permittivity-predicted measurements to estimate fermentation health.

In the second stage of experimentation, heat-stress of the yeast culture was carried out by heating the broth to 41°C. Cellometer results showed minimal reduction in cell counts. In contrast, the in-line permittivity sensor

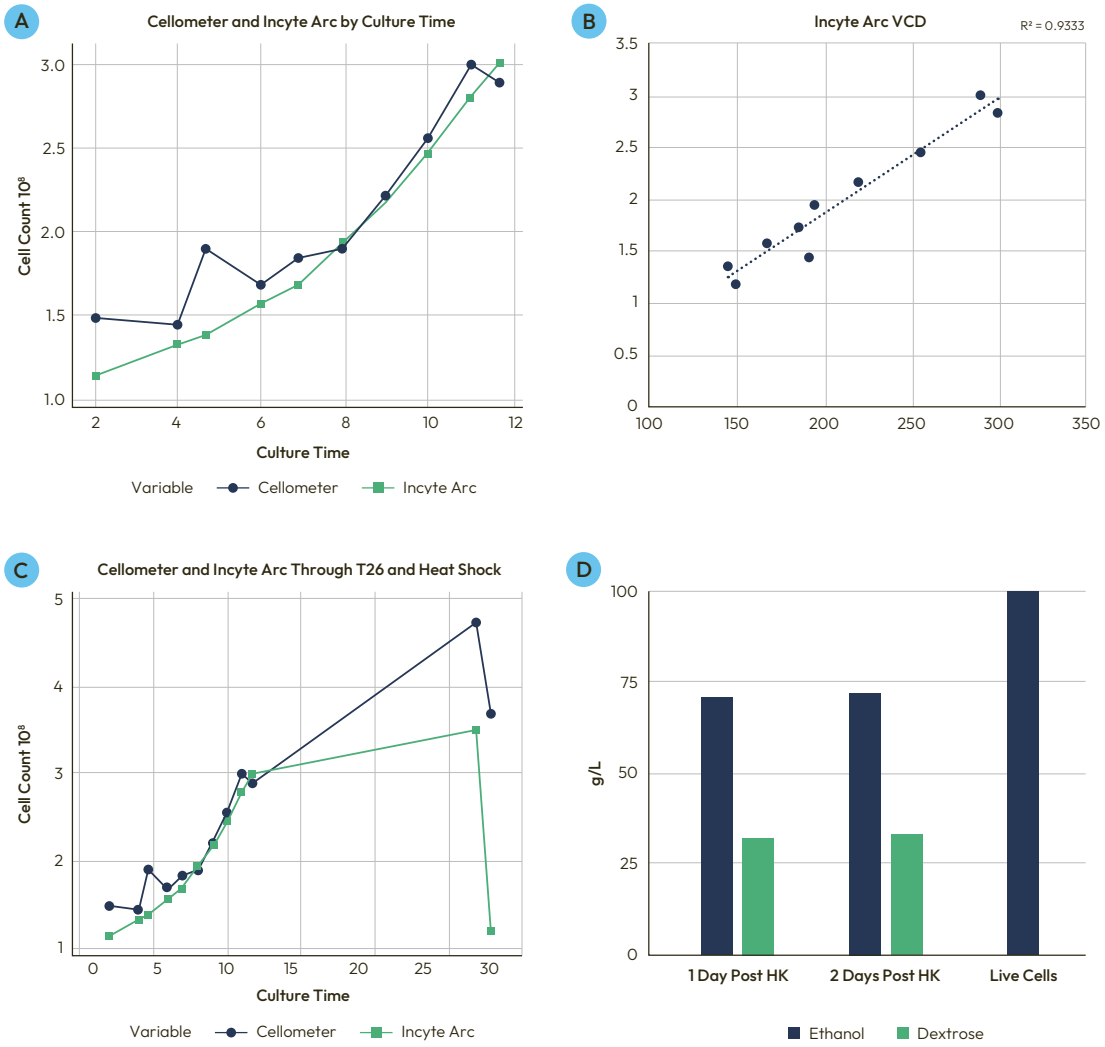

Figure 2:

A
Scatterplot illustrating inline/offline correlation during log phase.

B
Inline-offline correlation during growth phase (RMSE = 0.22).

C
Scatterplot illustrating inline/offline correlation through growth phase and heat stress.

D
HPLC Quantification of Ethanol and Dextrose Concentrations of 60 °C Heat-kill vs Live Yeast.

measurement decreased to near zero, indicating an almost complete loss of VCD (Figure 2C). As a third confirmation metric of yeast cell death, culture samples were collected before and after heating to 60 °C and incubated at room temperature for two days. The control yeast culture showed evidence of ethanol production while the heated sample did not, confirming the death of the yeast (Figure 2D).

This study confirms that the Incyte Arc delivers the real-time, accurate live yeast cell counts essential for process optimization. Moving forward, Cargill will continue to explore how the use of VCD probes and sensor-driven automation can improve operational efficiency and improve resource needs for propagation and fermentation.

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