Hyperpolarized xenon at 10 liters per hour for diagnostic MRI

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Abstract

We have completed development of a compact system for high volume production of hyperpolarized xenon (MagniXene™). Preparations to build production units for the first customers have started. The system is based on the existing 1 liter/hr Xemed XeBox-B polarizer. Its 2" diameter glass column was replaced by a 6" square copper column for increased gas flow and dissipation of heat from the 800 Watt wavelength narrowed CW laser. An on-board computer controls the polarizer. Automated operation is facilitated by a web-based interface. Compliance with FDA 21 CFR 210 and 21 CFR 211 is anticipated.

Introduction

Hyperpolarized xenon offers extraordinary potential as a contrast agent for MRI. The patented counter-flow xenon polarizer developed at the University of New Hampshire[1] and commercialized at Xemed LLC in the form of the XeBox-B™[2] system, has been scaled up in capacity. The cross section of the column, and the power of the laser were increased significantly, with only a small increase in overall size of the polarizer.

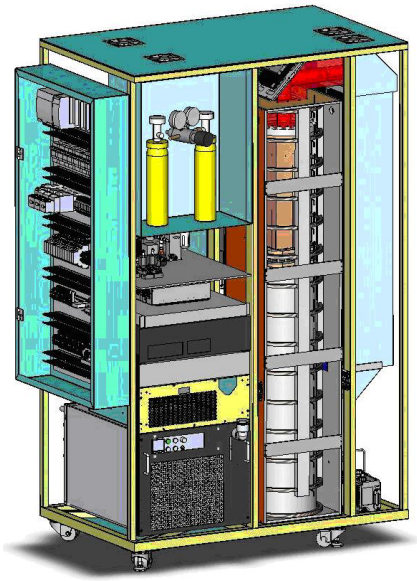

Figure1. XeBox-E10™ polarizer

Specifications and performance

The polarizer is equipped with a rising dewar xenon freezeout system, which minimizes polarization losses and collects pure MagniXene™ in a gas bag for easy transport to a patient. A calibrated 100 ppm accurate permanent magnet NMR system measures polarization level.

Polarization figures are presented in figure 2 as a function of xenon flow (standard liters per hour, slph) for three different laser power settings. At 6 slph polarization was measured at 56.4% on the prototype unit, which may improve as some items are refined in production. Higher rates are possible at reduced polarization, and higher polarization at lower rates.

Operation/Automation

A PC-based automation system monitors and controls all polarizer functions while presenting a simple, abstract user interface (UI.) A gas bag connects to the polarizer with a quick release coupling. The user chooses the amount of MagniXene™ desired and presses the "start" button to initiate the process. When the hyperpolarized xenon ice is fully accumulated, the UI alerts the user that the xenon is ready to be sublimed into the bag. Pressing the "fill gas bag" button quickly thaws the xenon into the bag, allowing the user to detach the bag and carry it to the patient.

An active monitoring system keeps track of performance and service needs. For example, the user will be alerted well in advance before gas tanks become empty or liquid nitrogen runs out. Polarization is measured before and after accumulation and can be compared to the user's own measurements.

Laser safety and enclosure access interlocks are implemented that prevent laser restarting without manual intervention following a power interruption, a requirement of FDA CFR 21 Part 1040.10.

Maintenance

The polarizer requires periodic maintenance for calibration and cleaning/reloading. Removing and reinserting the polarizing column is simplified by a tilting mechanism that does not require additional ceiling height for this operation.

Summary and outlook

First units of the XeBox-E10™ will be assembled and delivered to customers by third quarter 2008. We expect to increase laser power in the future to bring the production rate into the 20 liters per minute realm. A rubidium management system is under development.

Acknowledgements

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References

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2. J. H. Distelbrink, H. Zhu, K. MacArthur, F. W. Hersman, ISMRM 13th Meeting, p1838 (2005)

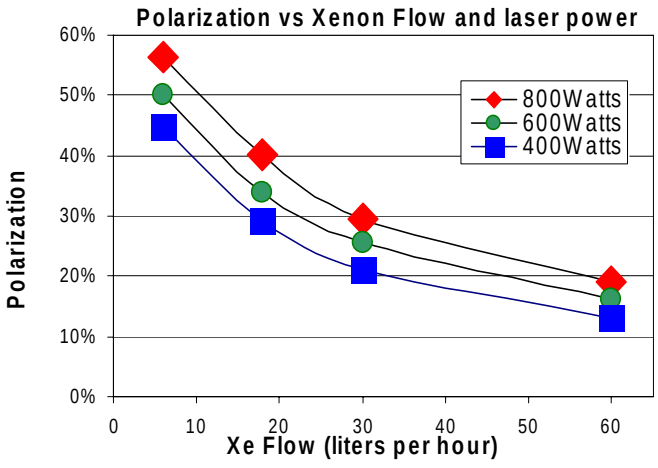

Figure 2 Polarization vs. xenon flow rate. Total pressure 130 Torr.