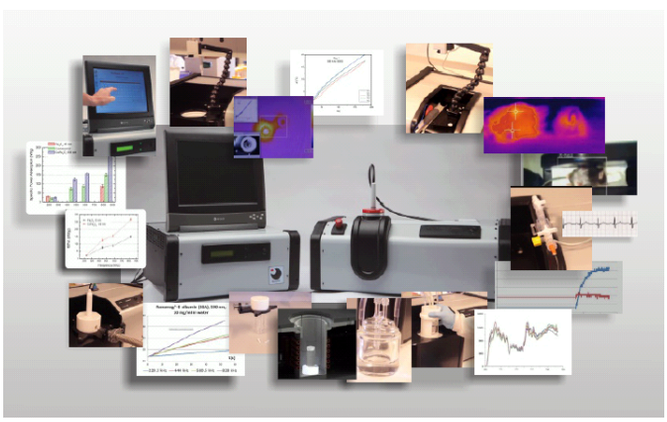
DM100 series
Instruments for
Magnetic nanoHeating

Literature review

Some experiences reported by DM100 users

Application Note #06



Introduction

If you are considering getting instrumentation for magnetic heating of nPs, magnetic hyperthermia or magnetically controlled drug release, we encourage you to read on.

Heating nanoparticles using alternating magnetic fields has become increasingly more commercially relevant every year so in the spring of 2011 nB introduced the concept of the DM100 Series product to the scientific community; our intention was to learn from the scientist's requirements and to make instrumentation that evolves with its users.

From the original DM1 applicator for calorimetry, and all the way down to the current catalog of applicators and accessories that enable calorimetry, local thermometry, thermal imaging, atmosphere control, temperature control, thermalization, heartbeat control for in vivo experiments, multiple probing, etc, the DM100 Series has proven nB's commitment to quality, reliability and, above all, constant innovation.

In this document, we'll briefly comment on a handful of scientific publications that users have shared with us which have been using DM100 instruments, as well as some in-house applicators and accessories.

The DM100 Series

DM100 Series is a set of instruments, accessories and software tools that can be combined to form different configurations covering every kind of Magnetic Hyperthermia and Magnetic nanoHeating experimental setup. Each DM100 configuration is a complete workstation that allows you to automatically run complex tests, register data and analyze your results.

DM100 Series systems have a modular concept. One controller can be used to drive multiple applicators –but not simultaneously. In the next page you'll find a quick guide to rapidly view the different alternatives and how your DM100 system must to be configured.

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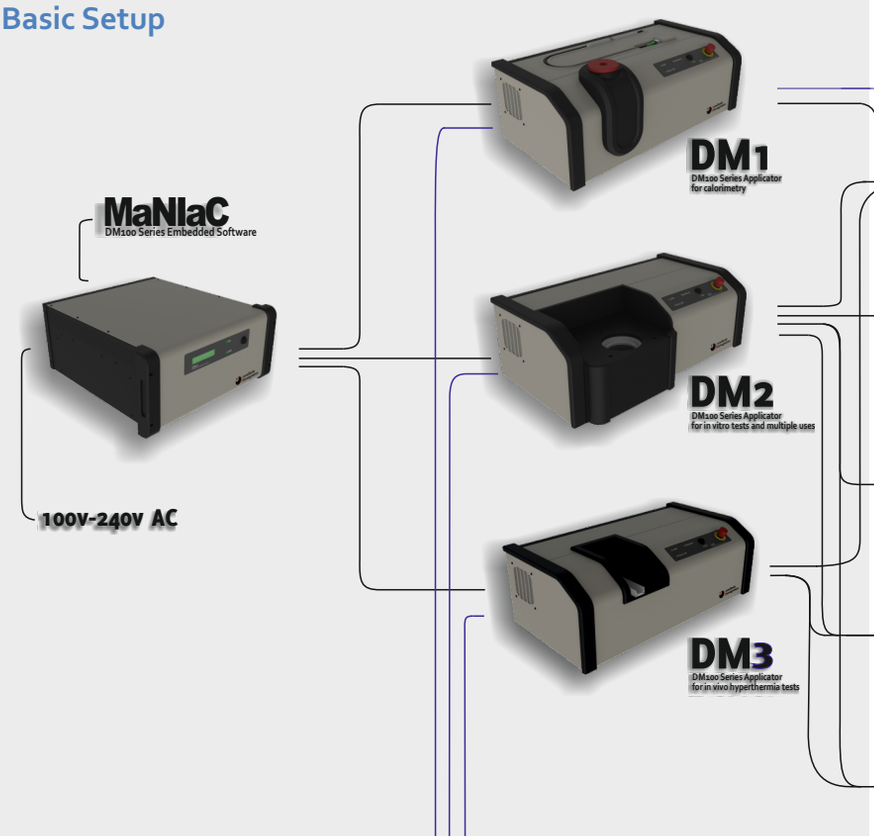
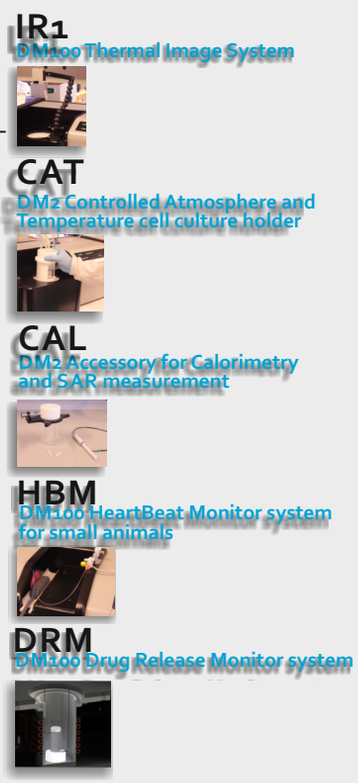
Basic Setup



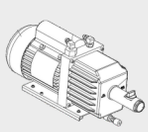
Accessories



Mandatory third party gear

Water chiller

Recommended third party gear



Rotary or turbomolecular vacuum pump
(recommended for calorimetry)

A general introduction to the different applicators can be seen in https://vimeo.com/71092494

Materials characterization

The most popular study in magnetic heating of nanomaterials is the measurement of the SAR (Specific Absorption Rate), also known as SPA (Specific Power Absorption). This parameter represents the power dissipated by a sample when it is exposed to a given applied magnetic field. The samples studied are mainly magnetic colloids, usually water based (but can also be in organic or acid solvents). SAR is expressed in [Watt/gr], and depends on concentration, solvent, field frequency, field intensity, field harmonic composition, aggregation for a given type of nanoparticle . Composition of the nanoparticle as well as size and shape also effect SAR.

The vast majority of publications dedicated to the study and report of SAR values of magnetic colloids indicate calorimetry as the method of choice. This method assumes that all the energy dissipated by the particles is finally transformed into heat which once dissipated across the sample's liquid base solvent, induces a rise of temperature that can be measured. In conditions of perfect insulation, the dissipated heat energy can be easily calculated by means of the experiment duration, specific heat of the base liquid and the change in temperature of the colloid. The SAR/SPA of the particles will then be calculated from the colloidal concentration and the parameters of the field.

.This procedure, although apparently simple, presents several challenges. In the initial years of scientific experimentation, the difficulty related to getting reliable, and particularly, repeatable results became evident as more and more papers were published. When nB designed DM1 -the applicator for calorimetry-, we were already aware of the crucial role that the quality of the magnetic field instruments, measuring probes and thermal facilities played in accurate SAR determination.

The influence of particle size on SAR was studied and reported by Goya, Lima et al. in 2008 using the first version of DM1 developed in collaboration with the Institute of Nanoscience of Aragón. In 2009, González-Fernández (from CSIC-Madrid) et al reported their work on optimization of size, shape and magnetic properties for improving SAR. In 2011, Torres et al presented their work with CoFe2O4 nanoparticles.

After the first commercial units were sold, in 2011 Sebastian et al. reported the magnetically-driven selective synthesis of Au clusters on Fe3O4 nanoparticles using DM1. The process allows growing gold selectively onto the heated magnetite surface, while keeping the synthesis solution comparatively cold.

Focused on core-shell type of particles, Zamora-Mora et al characterized chitosan and iron oxide nanoparticles for magnetic hyperthermia. Chitosan is one of the most frequent materials in core-shell particles, and is under study as a biocompatible nanoparticle coating for hyperthermia, contrast agent and drug release.

Guardia developed and published in 2014 a method for manufacturing an interesting kind of iron oxide nanocrystals with high SAR values with great potential for cancer therapy.

nB has collaborated actively with customers and leading researchers. Beatriz Sanz Sague, our lab specialist, has authored several papers in the hyperthermia research area framework. Another interesting example is the work leaded by Dr Seemann on the properties of FePt core shell nPs, or her study of the long term stability of colloids for magnetic heating, where nB's product Magno was included and compared.

Clinic, biology and biochemistry.

Our DM100 range of instruments is designed to fulfill the needs coming from every potential lab experiment regarding magnetic heating of nPs. In particular, DM2 and DM3 are focused on in vitro and in vivo procedures respectively. These instruments were introduced the market in late 2013 and 2014, and presently they have surpassed DM1 in interest and success in the research community. More than a dozen teams are already running preclinical procedures and biological validations using DM2 and DM3. Research groups have already published some promising data coming from the operation of these instruments. Other researchers have managed to use DM1 for biosamples, like cells in suspension.

In 2011 and 2012, Marcos Campos et al. presented their results on hyperthermia tests on dendritic cells. In 2012, Asín unveiled some very interesting results showing cell death induced by magnetic heating of nanoparticles without noticeable temperature rise.

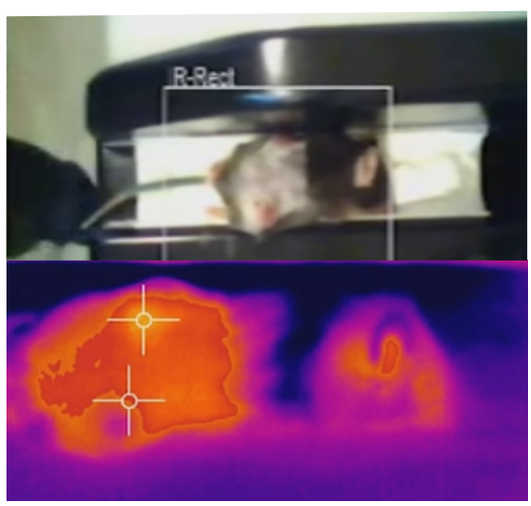
In the area of drug release, Hoare developed a magnetically triggered composite membrane for on-demand release, that was reported in 2009, and after optimization, in 2011. And in 2014, Carregal-Romero developed a microcapsule loaded with MnPs capable of releasing a molecular cargo.

One original contribution to what today is being called nanothermometry was made by Dias et al. when a method for using DNA as a molecular probe was presented in 2013> The group comparing calculations and thermal experiments with the data collected with DM1.

Functionalization is one of the most important areas of interest for researchers using magnetic heating of nanomaterials. From release, to labeling or just biocompatibility, many papers have addressed this task to help save the gap between the pure magnetic material and the bioapplication. In 2014, Radovic et al. reported the in vivo evaluation of multifunctional Y-labeled MnPs for cancer applications.

Finally, DM3, our in vivo applicator, is being used in some leading laboratories across Europe in countries such as France, Italy, Germany and Spain. Since the DM3 instrument is relatively new, results coming from its users are yet to be published by the researchers. We hope we can update this document soon with them. Nevertheless, some preliminary experiences can be seen in our DM3 promotional video, in

https://vimeo.com/81433677



Caption from DM3 promotional video

Conclusion

This document was mainly written thanks to the collaboration and support of the authors of the cited works. Even when no protected content is shared here, the authors were kind to communicate to us about their activities and publications. Many of them are close collaborators of ours, sharing research projects and products development. We know that many other researchers in America, Europe and Asia are getting more and more data us in our DM100 systems.

We are always pleased to know about what DM100 instruments are being used for, so if you are one of our users and would like to share your experience with us we will be happy to feature your achievements in future editions of this review.

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