Text of Most Recent USDA SBIR Project Abstract
Provenance PaperSaver Project*

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PAPER CONSERVATION BY NEW MASS DEACIDIFICATION TECHNIQUES-PHASE II

NON-TECHNICAL SUMMARY: Thousands of books and manuscripts in our libraries and archives are lost each year to yellowing and embrittlement rendering them unusable. The purpose of this project is to mass deacidify books and papers at risk with an in-house, cost-effective new method that will prevent this deterioration.

OBJECTIVES: The overall objective of our Phase II research program is to produce a prototype that utilizes this method to deacidify paper, and prevent ongoing, in-situ acid degradation that is rendering it unstable.

The workflow can be divided into A) Mission and B) Technical Objectives.

Mission Objectives:

The Library of Congress (LOC) provided the mission objectives for a successful MD treatment in 1990 by issuing a Request for Proposal (RFP) detailing five required performance criteria for an acceptable MD process. Those RFP criteria have been widely adopted and are summarized below:

1. The process must be demonstrated as effective for mass deacidification.

2. The scientific soundness and safety of the process must be substantiated throughout with supporting data.

3. The process must add to the necessary alkaline reserve, treat substrates uniformly and not cause damage to the paper or bound volumes treated.

4. The process must demonstrate satisfactory levels of quality assurance.

5. The process must provide documentation of appropriate inventory and tracking techniques for documents undergoing treatment.

Potential users have added criteria, which must be met by a process that is acceptable to their preservation department or institution as summarized below:

A. The process must be economically feasible for mass deacidification.

B. The process should be applicable for all materials without risk of damage to bindings, paper or ink.

C. The successful process must be capable of being carried out in-house by resident library personnel without the presence of extraneous hazardous chemicals or processes and without the necessity of exotic equipment or utilities.

Technical Objectives:

Most of the work on technical objectives will take place using a scaled-up prototype for the paper treating process. These include:

1. Development of real-scale equipment to study the application variables of the MD process as an aid in the engineering process and to assist in its commercialization.

2. Increased understanding of treatment parameters as well as the optimization of treating formulations.

3. Development and control of a method to uniformly apply treating formulation.

4. Increase in the effectiveness of the treatments.

5. Continued research into the effects of treatments on the properties of treated paper utilizing accepted physical testing protocols and Scanning Electron Microscopy with visual and energy dispersive X-Ray characterizations.

The technology above includes development, integration and proof testing of necessary prototype components and sub-systems. This will supply a satisfactory device for treating of single sheets of paper.

APPROACH: The approach to producing a prototype capable of treating paper will involve parallel laboratory studies and engineering development. Laboratory studies will be conducted with the bench-scale unit developed in Phase I and continue with early prototype model designs. The physical and chemical research deals primarily with factors affecting the treatment of the paper and the effects of treatment on that paper. These will be evaluated, by methods consistent with the experimental design and optimization techniques such an Advanced Experimental Design, Response Surface Methodology and Statistical Analysis. The effect of these factors are evaluated by standard accepted test protocols.

The variables to be studied in Phase II include those identified in Phase I (frequency, power, time, concentration) plus additional factors including wave form and geometric variable related to treating chamber geometry to aid in the development of a working prototype. The work will be specifically directed to locate variables, levels of variables and/or combinations of variables that will most effectively enhance the activity of aerosol treating beds of sub-micron alkaline particles.

Responses of paper samples are determined in this work by treating a population of recommended paper types and held to the requirements for an acceptable mass deacidification process published by the Library of Congress in their 1990 Request for Proposal. For threshold and target values, the concentration of the bed and time of exposure is determined to raise the pH of acid paper (pH 4 to 5) about 3-4 units while adding the required alkaline reserve of magnesium oxide. Other tests include qualitative evaluations of image and print quality retention, feel and appearance.

Engineering involves the design of five main modules making up the prototype such as the process chamber, loading sub-system, unloading sub-system, service module and the control system. Actual treatment of paper takes place in the process chamber, while the loading and unloading sub-systems control paper flow through the process. The service module is assigned the task of supplying treating formulation to the process chamber. Finally, control is achieved by process sensors such as those for temperature, humidity, and powder density.

Sensors are required to measure the physical properties of the process environment, in order to optimize the process parameters. The exact requirement for sensors in the final architecture, will be determined as part of the system and process characterization. These sensors are commercially available and will not require unique development in Phase II work. The control module also includes

the controller unit for the drivers, the drivers, GUI (graphic user interface), operational, control and system software. All of these systems are to be designed with CAD/CAM (computer aided design/computer aided manufacturing) and rapid prototyping techniques.

All the engineering work will be linked with the physical and chemical testing of the paper to ensure quality treatments, without detectable alteration to the paper, in the shortest time.

PROGRESS: 10/2005 TO 9/2006

The overall objective of this Phase II SBIR project is to create a working prototype unit the will effectively deacidify paper sheets at library and archive sites without using liquid carriers or exotic chemicals or process conditions. Recently, that objective has been achieved at treatment rates of up to four pages per minute with an operating first-generation prototype utilizing proprietary nano-particle based treating formulations.

Samples of acid paper treated using the SBIR sponsored developmental technology are currently being subjected to pre-conditioning and accelerated aging conditions as called for in standard test methods used to judge the effectiveness of preservation processes proposed for treating acid papers.

Following the required aging, incremental mechanical testing will take place to accurately determine the degree of effectiveness of the new process. Variables being studied include treating times/application rates of alkaline oxide treating chemical formulations as well as other proprietary variables thought to govern treatment outcome.

To date, conversions of the alkaline oxide treating formulations to alkaline hydroxides and carbonates have taken place over periods of less than 30 days as anticipated by theories of passive deacidification. Double-fold mechanical testing is being used to determine treatment effectiveness and calculate a life extension factor and measurements of alkaline reserve added to paper substrates are also being carried out. Scanning electron microscopy will be used to determine morphology of papers treated with the new process.

IMPACT: 10/2005 TO 9/2006

The expected impact of this work will take place on two levels. In the short term, development of the prototype unit and suitable results from screening testing now going on will provide impetus to develop more refined prototypes. These can in

the next 1-2 years be used on site at libraries and archives to treat collections of at-risk acid documents. This equipment will also provide an economical and easy to use way to address the huge backlog of documents needing treatment.

At the second, longer term level, the new technology will encourage commitment of funds for preservation which are not available currently being allocated to preservation. This paradigm shift can occur now because heretofore virtually all libraries and archives could not use the existing technologies available on a large scale because they are not cost effective. A second long term potential impact will be the combination of this new technology to preserve existing original documents at the same time and as part of the same workflow process used to digitally reproduce and store at risk materials printed on acid paper.

PUBLICATIONS: 2005/10 TO 2006/09
No publications reported this period

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1. To get to the project summary go to http://cris.csrees.usda.gov/menu.html

2. When at that site, select "assisted search" and then - in the field "Fulltext Terms" enter "paper deacidification" and click the search button.

3. The interface will tell you that 2 records have been retrieved. Click the "display results" button next.

4. Check "select" on the selection number "0192880" and click on "More".