DOMINO

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**DOM01** March 2008

**DOMINO Workplans for 2007-2008** (Draft Workplans released in December 2007)

Gűl N. Őzcan

**DOM02** February 2008

**Dispersion of Nanoparticle Clusters in Liquids**

Gűl N. Őzcan

**Executive Summary**

This report is prepared for DOMINO members to provide background on the break up of nanoparticle clusters in a liquid. Following on from a description of the process, the incorporation of nanoparticles in a liquid and break up of these are presented. Information on the different types of equipment widely used in industry is also given.

**DOM03** March 2008

**Rheology of Fine Particle Suspensions**

Neil J Alderman

**DOM04** April 2008

**Draft Design Procedures for the Dispersion of Nanoparticle Clusters**

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**DOM05** November 2008

**Effect of Rotor-stator Geometry on Power and Flow Characteristics of Three in-line Rotor-Stators**

Gűl N. Őzcan, Dominik Kubicki, Gustavo Padron

**Executive Summary**

This report details the results of a study undertaken within DOMINO on the power and flow characteristics of three in-line rotor-stators. These devices were also used to investigate the break up process of nanoparticle clusters within DOMINO.

The overall objective of the single phase study has been to:

highlight the differences in the power and flow characteristics of three different mixer heads which would contribute towards the explanation of the results from break-up studies and ultimately on the discussions related to the choice of mixer head for this application.

The three devices studied were:

- inner General Purpose Disintegrating Head (GPDH) and an outer Square Hole Screen (SQHS),
- dual Emulsor screen (EMSC) from Silverson and
- Z unit from Ytron.

**DOM06** May 2009

**Effect of rotor-stator geometry on break up of silica nanoparticle clusters**

Gűl N. Őzcan, Gustavo Padron

**Executive Summary**

In-line rotor-stator mixers are used in a wide range of energy intensive applications in the chemicals, food, personal, health care and applications numerous other applications for foam generation, chemical reactions, break up of liquid droplets or particle clusters. However there is limited published work on their performance and often process design and equipment selection must be done on a trial-and-error basis. This report presents the results of our study on the comparative performance of three different rotor-stator geometries for the break-up of nanoscale fumed silica clusters:

- Silverson/GPDH-SQHS,
- Silverson/EMSC and
- Ytron Z.

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**DOM07** December 2008

**DOMINO Workplans for 2008-2009**

Gűl N. Őzcan

**Executive Summary**

This document provides the details of the work programme of DOMINO 2008-09 proposed for voting to the consortium members. Following on from a description of the project, the outlines of the proposed Work Packages are given in Section 3. The document will be finalised after the votes are received and work programme finalised based on this.

**DOM08** December 2008

**Results from preliminary experiments with two nanoclays**

Neil J Alderman, Ainee Cheah, N. Gűl Őzcan, Gustavo Padron

**Executive Summary**

In this report, findings from an initial study with two nanoclays are presented.

Either an ultrasonic device or a stirred vessel equipped with a sawtooth impeller was used to prepare the dispersions. Samples taken at regular intervals under different operating conditions have been analysed through particle size measurements, X-Ray diffraction, rheology measurements and electron microscopy to monitor the dispersion process.

**DOM09** June 2009

**Particle-liquid affinity- DOMINO Results from 2007-08**

Neil J Alderman, Ainee Cheah, N. Gűl Őzcan, Gustavo Padron

**Executive Summary**

In this report, findings from the first year programme of DOMINO are presented on particle-liquid affinity. The study was carried out using two types of nanoscale fumed silica particles:

- Aerosil 200V (hydrophilic)
- Aerosil R816

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in two liquids, both of a similar viscosity of about 10 mPa s:

- glycerol solution and
- silicone oil

Findings on incorporation of particles in a stirred tank using a narrow blade hydrofoil, rheology of dispersions from break up experiments and break up kinetics obtained using a large scale in-line rotor-stator and a small scale ultrasonic disperser are reported.

**DOM10** June 2009

**Results from preliminary experiments on break up of nanoscale silica particles using the Microfluidics M-110P**

Dominik Kubicki

**Executive Summary**

This report details the preliminary results on the breakage of nanoscale silica particle clusters in a microfluidizer, Microfluidics M-110P.

The objectives of this work have been to:

- determine the range of operating conditions
- identify any difficulties that may be encountered during equipment operation and
- make an initial assessment of the performance of this device.

**DOM11** June 2009

**Results of a preliminary study on particle incorporation using the Ytron Y Jet Mixer**

N. Gűl Őzcan

**Executive Summary**

Findings from a preliminary study on the incorporation of nanoscale silica particles using the Ytron Y Jet mixer are presented in this report. The study was carried out within the work package C1 of DOMINO 2008-09 programme at a low solids concentration of 1% (w:w) and within B.2- Effect of solids concentration for higher concentrations of up to 10%.

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Ytron Y Jet device consists of an axial flow impeller mounted in a draft tube (or stator) positioned off-centre, close to the base of an unbaffled tank. A feed tube connected to a funnel (or hopper as referred to by manufacturers) is intended to introduce the particles into the impeller region.

A small scale vessel of 0.29 m diameter was used for the study. Experimental work included determining:

- power characteristics for different configurations;
- surface aeration conditions;
- drawdown rate over a range of power input values;
- effect of vessel and mixer unit configuration and
- effect of solids concentration.

Results and overall trends are also compared with the published data from another project, PROFORM.

**DOM12** December 2009

**DOMINO Final Workplans for 2009-2010**

N. Gűl Őzcan

**Executive Summary**

This document details the work programme of DOMINO for 2009-10.

**DOM13** January 2010

**Effect of dispersion methods on the delamination of two types of nanoclay (Cloisite 30B in Daltocel and Cloisite Na+ in water)**

Neil J Alderman, Ainee Cheah, N. Gűl Őzcan, Gustavo Padron

**Executive Summary**

In this report, findings from a study on the importance of different dispersion technologies are presented for two types of nanoclay dispersions.

The dispersion devices used were:

1. Hielscher UP200S 24kHz ultrasound disperser in a tank fitted with a PBT covering a specific power input range of about 40-80 $Wkg^{-1}$;

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2. Lightnin A310 impeller in a tank at a specific power input of about 0.1 $Wkg^{-1}$;

3. saw tooth high shear impeller in a tank at a specific power input of about 5 $Wkg^{-1}$;
4. Hielscher UP200S 24kHz ultrasound disperser within a flow cell in the circulation loop of a stirred tank equipped with the large ICI impeller covering a specific power input range of about 40-80 $Wkg^{-1}$.

Samples taken at regular intervals under different operating conditions have been analysed through particle size measurements, X-Ray diffraction, rheology measurements and electron microscopy to monitor the dispersion process.

**DOM14** March 2010

**Literature review on break up of nanoparticle clusters with high pressure jets and valve Homogenisers**

N. Gűl Őzcan

This report provides a review of literature on the break up of nanoparticle clusters using high pressure jets and valve homogenisers.

**DOM15** February 2010

**Literature review on break up of nanoparticle clusters using stirred bead mills**

Emmanuela Gavi

This report is prepared for DOMINO members to provide background on stirred bead mills and on their application for efficient nanoparticle dispersion. Following on from a description of the equipment, its working principles and operating conditions, some recent advances on nanomilling and modelling of the grinding process in the bead mill are discussed. Information on the different types of equipment widely used in industry is also given.

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**DOM16** April 2010

**Effect of residence time in an in-line rotor-stator on break up of silica nanoparticle clusters**

Gustavo Padron

In-line rotor-stator mixers are used in a wide range of energy intensive applications in the chemicals, food, personal, health care applications and numerous other applications for example, foam generation, chemical reactions, break up of liquid droplets or particle clusters. However, there is limited published work on their performance and often process design and equipment selection must be done on a trial-and-error basis.

This report evaluates the effect of residence time within the rotor-stator on the de-agglomeration of fumed silica clusters. The rotor-stator used was a Silverson 150/250MS with a dual EMSC stator. Residence time was varied by either changing the batch size or flow rate.

**DOM17** May 2010

**Preliminary experiments with hydrophilic and hydrophobic zinc oxides**

Gustavo Padron

**Executive Summary**

Zinc oxide has many industrial applications such as cosmetic UV protection and the production of UV-protected coatings and polymers. It has also potential uses in areas such as cross-linking, chemical catalysis and corrosion protection. It is therefore of interest to determine the best ways to finely disperse ZnO particles in order to take full advantage of their potential.

This document reports the findings from the studies undertaken within DOMINO in 2007-08 and 2008-09 using different types of zinc oxide.

Work has been carried out with three zinc oxides: two naturally hydrophilic manufactured by different processes and one whose surface has been treated to become hydrophobic (VP AdNano Z 805). Also, three different dispersing agents have been tested. The dispersions were produced using an ultrasound disperser. Results for particle size, viscosity, zeta potential and SEM imaging will be shown.

An optimised PSD measurement procedure was developed for ZnO dispersions due to their tendency to dissolve and/or settle during analysis. This was done to ensure the reliability of the results.

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**DOM18** May 2010

**Population Balance Balance Modelling of the break up of nanoscale silica agglomerates using an in-line rotor-stator: effect of power input, flow rate and particle concentration**

Dominik Kubicki

**Executive Summary**

This report presents the results of numerical modelling of the nanoparticle breakage process. The breakage of Aerosil 200V nanoparticle clusters processed in an in-line rotor-stator device is modelled. The numerical model assumes a simple 1D flow pattern in the system. The evolution of particle size distribution is modelled using the discrete form of population balance equations. The results of numerical simulations are compared with experimental data.

Four different breakage mechanisms are studied: erosion, shattering, rupture and binary breakage.

Effects of three parameters are investigated: power input, flow rate and particle concentration.

**DOM19** May 2010

**Effect of Particle Concentration on the Performance of Microfluidizer for Breaking up Silica Particles**

Emmanuela Gavi

**Executive Summary**

Microfluidics M110-P was used within DOMINO in a preliminary study on the break up of a 1% silica dispersion (DOM10). Those first results raised sufficient interest to investigate further the performance of this device at higher particle concentrations. This has been the motivation of the study documented in this report.

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**DOM20** May 2010

**Effect of Continuous Phase Viscosity on Break Up of Silica Nanoparticles using Microfluidics M-110P**

Emmanuela Gavi

**Executive Summary**

Microfluidics M110-P was used within DOMINO in a preliminary study on the break up of a 1% silica dispersion and this study carried on the investigation and is aimed at testing the effectiveness of operation of the Microfluidizer with increasing continuous phase viscosity. The results are compared with previous results from Rotor-Stator and Ultrasonic devices.

**DOM21** August 2010

**Break up of Zinc Oxide Nanoparticle Clusters Using Surfactants and Microfluidics M-110P**

Emmanuela Gavi, Gustavo Padron

**Executive Summary**

This document reports the findings from the studies on the dispersion of zinc oxide clusters within DOMINO in 2009-10. Work carried out has two strands;

The first set of experiments was aimed at verifying if a polymeric surfactant with a high molecular weight, used in the early work during 2008-09, prevented zinc oxide agglomerates from breaking up by binding particles together. With this objective the stabilising agent Tergitol NP-9, was chosen because of its low molecular weight.

The second set of experiments aimed at verifying if a higher energy intensive device may achieve a higher fines volume fraction than the ultrasonic processor.

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**DOM22** October 2010

**Effect of Solids Concentration on Break Up of Silica Nanoparticle Clusters with an In-Line Rotor-Stator and an Ultrasound Disperser**

Neil Alderman, Dominik Kubicki, Gustavo A Padron

**Executive Summary**

Within DOMINO, in-line rotor-stators and ultrasound processors have been used to investigate the break up of nanoparticle clusters. Many nanoparticle break up applications require the processing of dispersions with high solids loadings. Therefore, it is important to understand how solids concentration affects the performance of the process equipment used.

In this report, results on the effect of solids concentrations up to 15%wt in an in-line rotor-stator mixer (Silverson 150/250MS) and an ultrasound disperser (Hielscher UP200S) on the de-agglomeration rate of fumed silica particle clusters are presented. The effect of solids concentration on dispersion rheology was also investigated and used in the interpretation of the break up results.

**DOM23** September 2010

**Particle-Liquid Affinity - DOMINO results from 2008-2010**

Ainee Cheah, Gustavo A Padron, Gul Ozcan-Taskin

**Executive Summary**

Findings from 2008 - 2010 programme of DOMINO on particle-liquid affinity are summarised in this report. These studies have been undertaken with a different continuous phase (Dipropylene glycol dimethylether) and a different type of hydrophobic nanoscale fumed silica (Aerosil® R202) particles.

Dipropylene glycol dimethylether (also known as DPGE in this report) was chosen because it has a solubility of 35wt% in water and therefore has intermediate properties compared to silicone oil and glycerol solutions used previously in DOMINO.

Another set of work was carried out with Aerosil® R202, which was chosen because its surface was modified with poly dimethylsiloxane, similar chemical structure to that of silicone oil.

The particle-fluid affinity, which is affected by the properties of both particles and continuous phase, can have a significant impact on particle break up.

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**DOM24** September 2010

**CFD model of flow generated by an ultrasonic disperser**

Dominik Kubicki

**Executive Summary**

This report presents the results of numerical modelling using Computational Fluid Dynamics (CFD) of the flow field generated using an ultrasonic disperser.

The model consists of two parts. First, the acoustic pressure distribution is solved using finite element solver Elmer, then acoustic pressure distribution is used to model cavitation in Fluent.

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