UOP Adsorbents

A FAMILY OF HIGH PERFORMANCE POWDERS

UOP Versal™ Alumina

UOP
A Honeywell Company

Versal™ Alumina

A FAMILY OF HIGH PERFORMANCE POWDERS

UOP, the largest commercial producer of precipitated aluminas in the world, offers a broad range of powders that can be manufactured to meet specific customer needs.

Typical applications include abrasives, polishes, washcoat slurries, binders, ceramic coatings, sol-gel ceramics, paper coatings and formed catalyst supports. The Versal product line includes pseudoboehmite, bayerite, gamma and alpha aluminas, and owes its versatility to the extensive physical and rheological differences of its applications. Ceramic and catalyst manufacturers now have the option of a range of alumina product properties including density, porosity, acid stability and thermal sintering characteristics to apply in a variety of applications.

Pseudoboehmite Aluminas

Versal pseudoboehmite aluminas are supplied as loosely agglomerated, easily dispersed, spray-dried powders (about 50 microns mean diameter) possessing high-purity, high surface area and low bulk density. Each Versal alumina particle is built from nominal 30 angstrom (3.0 nm) crystallites through a unique acid-base precipitation process using a proprietary reactor configuration that allows control of density, particle morphology, colloidal dispersibility and thermal conversion processes. Typical Versal pseudoboehmite properties are shown in the table below.

Versal Alumina Powders	Dispersibility Index[1] (%<1mu)	Bulk Density (lbs/ft^3)	Surface Area (m^2/g) (Calcined 600°C)	Na_2O Wt%	SiO_2 Wt%	Cl Wt%	LOI Wt%
V-250	20-30	12-16	320	<0.04	<0.15	<0.15	26
V-700	>65	25-37	310	<0.1	<0.15	<0.15	28

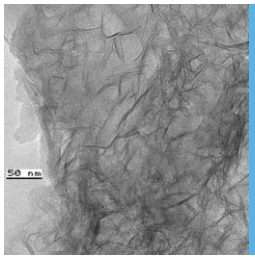
V-250 Powder

Versal V-250 powder, UOP's lowest density pseudoboehmite alumina, has a low Dispersibility Index[1]. V-250 is typically used to provide the highest macroporosity in ceramic or formed products. The V-250 manufacturing process produces a unique pseudoboehmite particle with a secondary structure that is porous and more thermally stable to high temperature phase conversion and sintering than the other Versal pseudoboehmite aluminas. This can be beneficial in a calcination process application requiring a softer abrasive particle with higher surface area that is essentially alpha alumina free and easily deagglomerated. When calcined to gamma (~600°C), theta (~1100°C) or alpha alumina (~1260°C), the uniquely soft or friable V-250 macroporous morphology is easily deagglomerated for use in abrasive applications and slurry formulations. Calcined V-250 powder can possess a range of hardness levels and friability characteristics depending on firing conditions.

[1]**UOP Dispersibility Index -** The Dispersibility Index test procedure for V-250 and V-700 uses 8 grams of sample on a volatile free basis and 96 ml of 0.22N nitric acid solution. (This is approximately 260 meq nitric acid per 100g alumina.) The acidic alumina slurry is mixed in a Waring blender at low speed (17000 rpm) for 5 min. The particle size distribution is then measured using a Sedigraph PSA and reported as Wt% submicron particles.

V-700 Powder

Versal V-700 powder is a mid-density pseudoboehmite that provides significantly higher dispersibility for use in colloidal alumina slurry polishing formulations, yet has low macroporosity for use in solid ceramics and abrasives. The V-700 crystallites of 3 nm are typically smaller and less ordered than the 4-10 nm crystallites found in alkoxide derived aluminas. The V-700 manufacturing process takes advantage of this morphology by reducing the low density pseudoboehmite secondary structure developed for V-250. Consequently, V-700 requires less severe firing conditions to achieve phases transitions than V-250 or alkoxide-derived aluminas. The lower temperatures required for the V-700 phase conversion can substantially lower thermal processing costs. Due to a friable morphology, calcined V-700 is easily deagglomerated for use in polishing and abrasive applications.



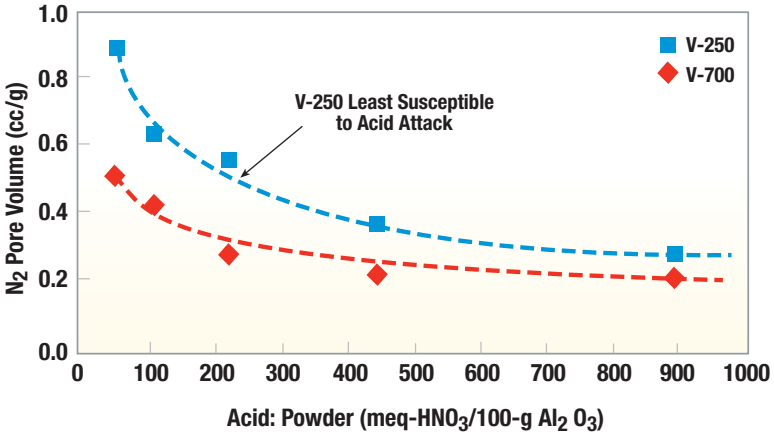
Typical Versal Pseudoboehmite Microstructure

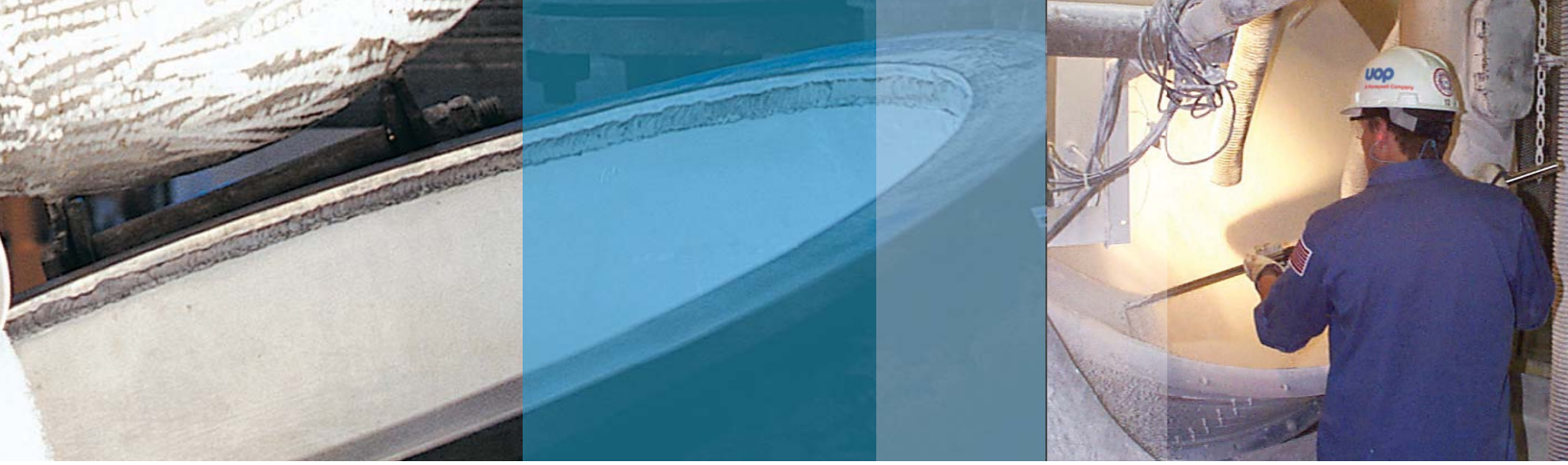
Versal Pseudoboehmite Peptization Chemistry

The comparative effects of peptization chemistry on Versal V-250 and V-700 are represented in the curves below. The high macroporosity built into the V-250 particle structure and its increased resistance to acid breakdown lead to a more porous, less dense calcined ceramic body when formed either by extrusion or other means. Even with increased acid levels, V-250 is capable of producing high macroporosity products. V-700 possess little secondary particle structure and are significantly more dispersible. V-700 can produce a range of higher strength, less porous calcined structures as-is or when peptized, dispersed and formed.

Comparative Effects of Peptization on V-250 & V-700 Aluminas

10 Wt% $A_{l2}O_3$ Slurry, Peptized, 100°C-Dried, 600°C-Calcined





Bayerite Alumina

Versal B high purity bayerite is a non-dispersible high density crystalline beta alumina trihydrate widely used in catalyst compositions requiring a high surface area calcined substrate with more acidity than gamma alumina. Calcination of crystalline bayerite leads to destruction of the original highly crystalline framework and evolves through high surface area alumina phases eta and theta before reaching alpha alumina.

Chemical Analysis

LOI Wt%	Density (lbs/ft^3)	Surface Area* (m^2/gm)	Particle Size (mu)	Na_2O Wt%	SiO_2 Wt%	Cl Wt%
35	35-55	370	30	<0.13	<0.15	<0.07

*Calcined @400°C

Bayerite is crystallized in a modification of the Versal alumina process and is supplied as a 30 micron spray-dried powder. UOP is the world's leading producer of low cost bayerite.

Gamma Alumina

Versal gamma aluminas are transition phase aluminas derived directly by calcination of the Versal pseudoboehmite product line. Versal gamma alumina represents a series of products with tailored surface area and abrasive characteristics dependent on customer needs. UOP manufactures VGL-15 and VGL-25 (from V-250 pseudoboehmite) as commercial products with different properties for evaluation in a variety of applications. Versal gamma alumina can be deagglomerated with milling or intensive mixing to smaller particles for use as an abrasive, slurry ingredient, and in alumina washcoating applications. The UOP Friability Index[2] in the properties table was developed using ultrasonication (Uls) and particle size measurements to rank relative hardness and ease of deagglomeration for UOP Versal products. The higher the Friability Index, the more easily the product is deagglomerated. The Friability Index is function of calcination conditions and the type of Versal product. In solid-liquid applications normally developed at pH 3-5, these products can produce slurries having high solids loading. Versal gamma alumina also has aqueous applications as thickening agents or as adsorbents. Due to the unique Versal pseudoboehmite precursor powders, Versal gamma alumina products tend to produce supports and films that have high macropore volume.

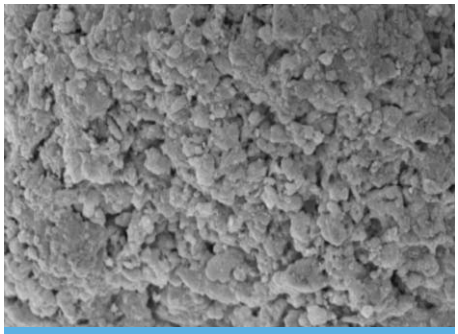
Properties

Starting Versal Alumina Powders		Loose Bulk Density (lbs/ft^3)	Surface Area* (m^2/gm) (As-is)	Pore Volume (cc/g)(As-is)	Friability Index[2]
VGL-15	V-250	12 (193 kg/m^3)	150	1.36	9-10
VGL-25	V-250	12 (193 kg/m^3)	250	1.32	9-10

*Surface area can be custom tailored for individual customer needs.

[2]UOP Friability Index - The Friability Index is the relative loss of >20 micron particles in a nominal 5 Wt% slurry of caused by ultrasonication. Approximately 20 ml of slurry is prepared by suspending 1g alumina in 20 ml deionized water. The weight-fraction of particles >20 microns ("Wt%(20)") is determined before and after ultrasonication at 90W for 4 minutes. The Friability Index is calculated by the following equation:

$$\text{Friability Index} = 10 \times \left[\frac{\text{(Wt\%(20) no-ultrasonication} - \text{Wt\%(20) with ultrasonication)}}{\text{Wt\%(20) no-ultrasonication}} \right]$$

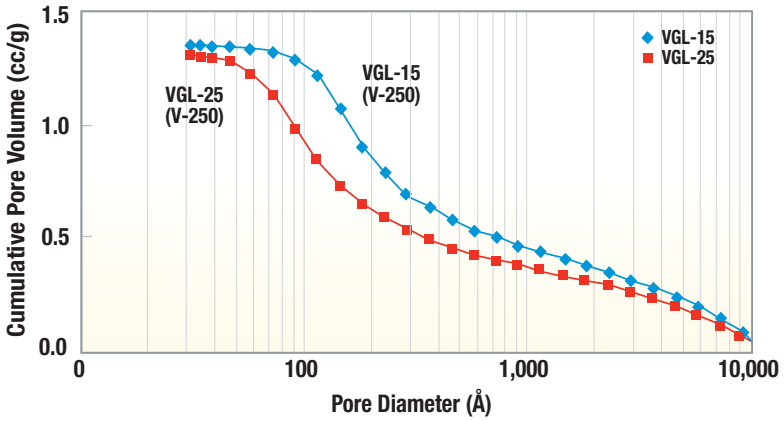


SEM Showing Typical Calcined Versal Alumina Macroporous Particle Morphology

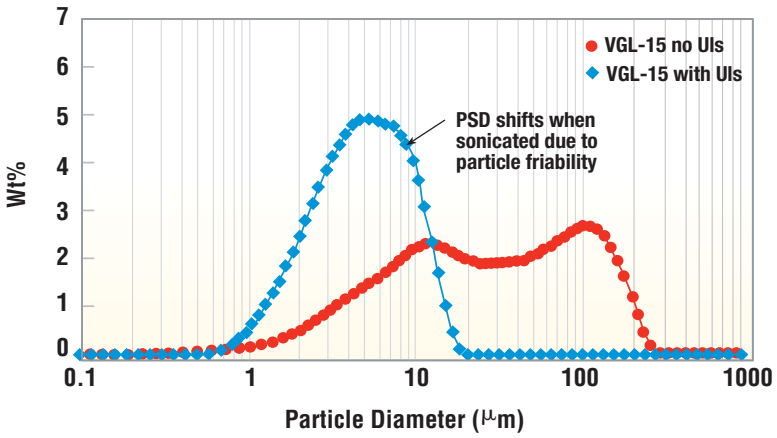
The ease of deagglomeration of calcined V-250 is illustrated by the friability measurements below of V-250 derived VGL-25.

Versal Gamma Alumina Powder

Meso- and Macro-prosity Comparison
(porosity corrected for powder pompaction)



Effects of Ultrasonication (UIs) on VGL-15 PSD



Alpha Alumina

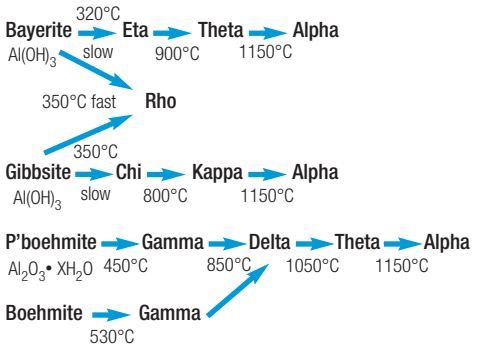
Versal alpha alumina is derived from high temperature calcination of Versal pseudoboehmite and bayerite aluminas. Since each application for alpha alumina can require variations in density, surface area, hardness and deagglomeration characteristics, UOP can custom manufacture calcined alumina from any chosen Versal alumina precursor. UOP offers a Versal alpha alumina prototype derived from V-250 pseudoboehmite that has an 8 m^2/gm surface area and may serve as a useful Versal alpha alumina starting material. As seen in the TEM photographs below, Versal alpha alumina derived from Versal pseudoboehmite will have a coral-like porous structure that can be easily deagglomerated and be beneficial in your manufacturing process or application.

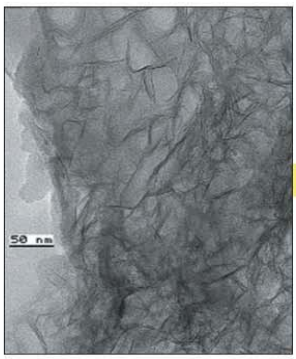
Versal Thermal Chemistry and Morphology

UOP's manufacturing process creates clusters of 3nm Versal pseudoboehmite crystallites that have been characterized as having a fibrous plate-like structure. Shown in the TEM data below, calcination of Versal pseudoboehmite alumina into the gamma phase manifests a substantial retention of the fibrous appearing plate-like morphology. The evolution of higher temperature transition phases transforms the morphology into a more distinct grain-like structure. Calcination to the alpha phase generates a porous, low density, coral-like microstructure that can be deagglomerated to smaller particles. The morphology of calcined bayerite resembles the porous structure of other Versal aluminas but is more faceted and has a higher degree of connectivity among the grains.

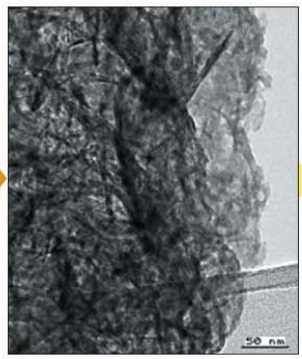
Alumina Phase Transformation

Oxides and Hydroxides of Alumina Calcination Chemistry

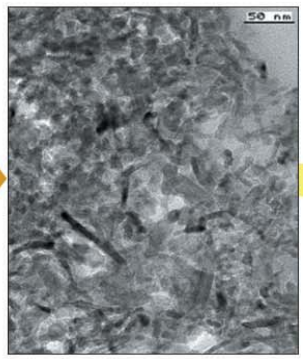




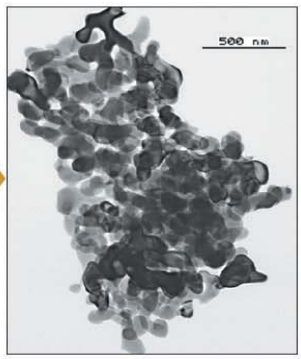
Typical Versa Pseudoboehmite



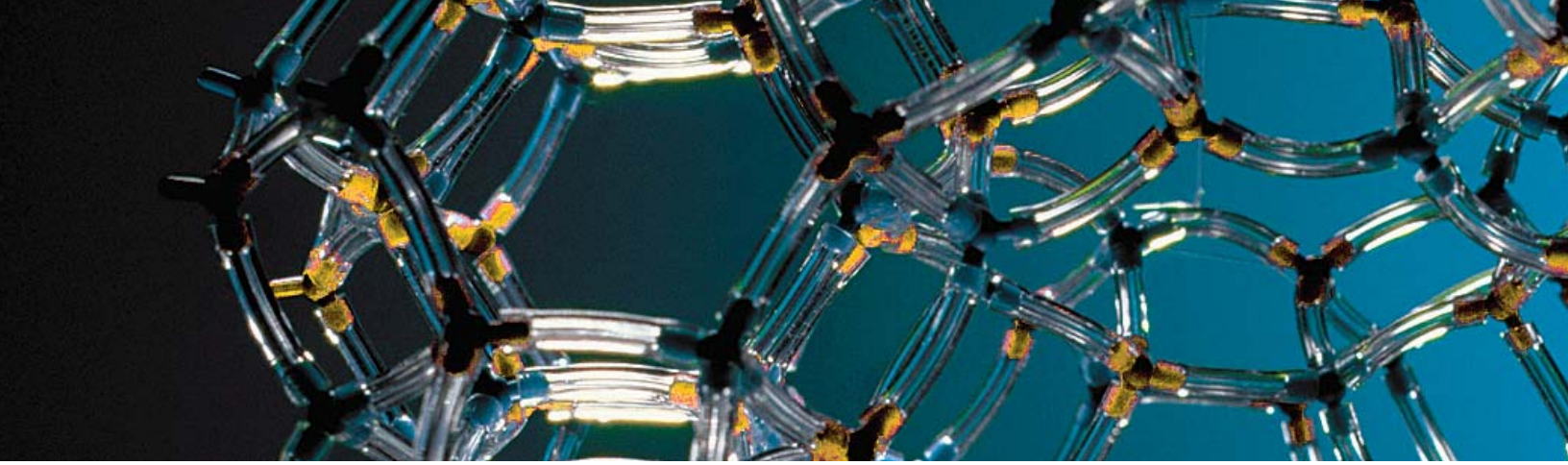
Versal Gamma Alumina (250 m^2/g)



Versal Transition Alumina (100 m^2/g)



Versal Alpha Alumina (8 m^2/g) Derived from Pseudoboehmite

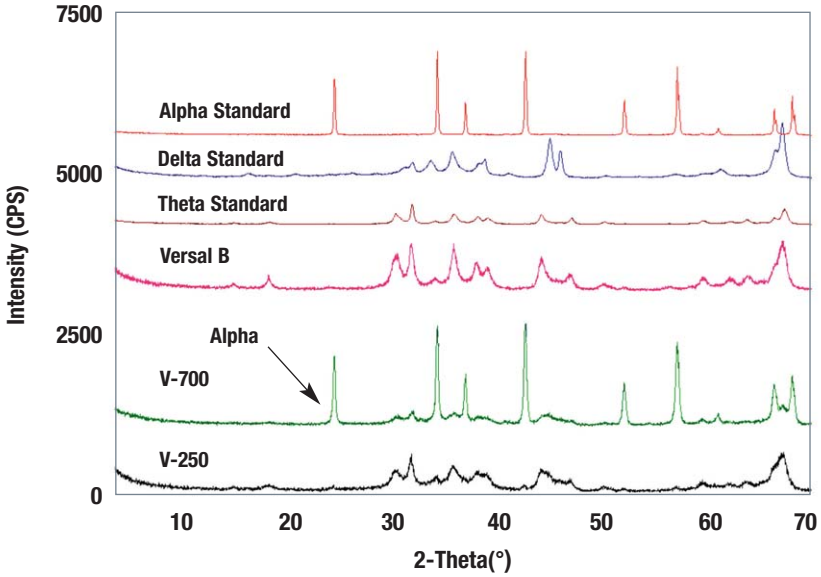


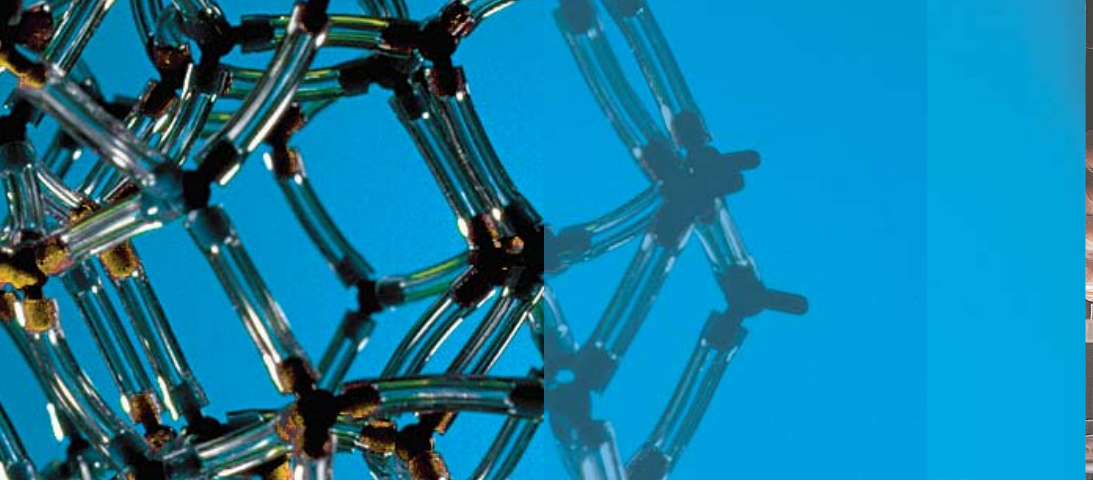
The table below illustrates the thermal conversion characteristics of V-250, V-700 and Versal B at various temperatures. The XRD patterns taken at 1100°C are shown as well. V-250 powder is resistant to lower temperature alpha conversion due to its unique secondary structure created in UOP's manufacturing process. This can be beneficial in a calcination process application requiring a softer abrasive particle with higher surface area that is essentially alpha alumina free and easily deagglomerated. V-250 readily converts to alpha alumina at 1260°C yet retains its high friability. V-700 and converts to alpha alumina at lower temperatures than V-250 (and alkoxide aluminas) and produce denser hard alpha particles. The friability of V-700 is intermediate to V-250. Versal B retains a transition alumina phase at 1100°C before converting to alpha alumina.

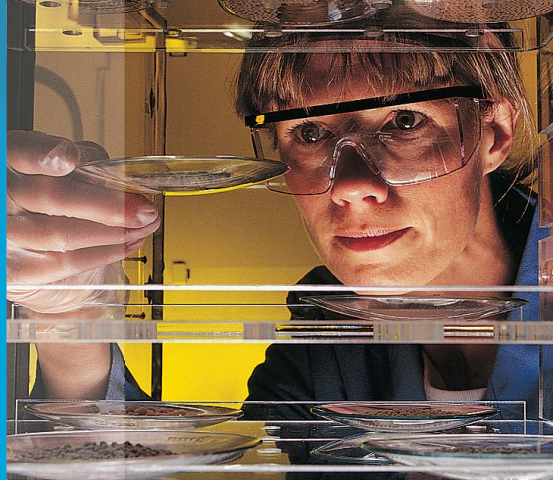
Grades	Surface Area @ 600°C 1hr (m^2/g)	Phase XRD @ 600°C 1hr	Surface Area @ 900°C 1hr (m^2/g)	Phase XRD @ 900°C 1hr	Surface Area @ 1100°C hr (m^2/g)	Phase XRD 1100°C hr	Surface Area @ 1260°C 1hr (m^2/g)	Phase XRD @ 1260°C 1hr	Friability Index Range
V-250	340	Gamma	205	Gamma	103	Theta	9.4	Alpha	8-10
V-700	290	Gamma	162	Gamma	51	50% Alpha	9.4	Alpha	4-6
Versal B	370*	Eta	150	Theta	88	Theta	8	Alpha	3-6

*Calcined @400°C

XRD Patterns of Various Versals Calcined at 1100°C for 1 Hour



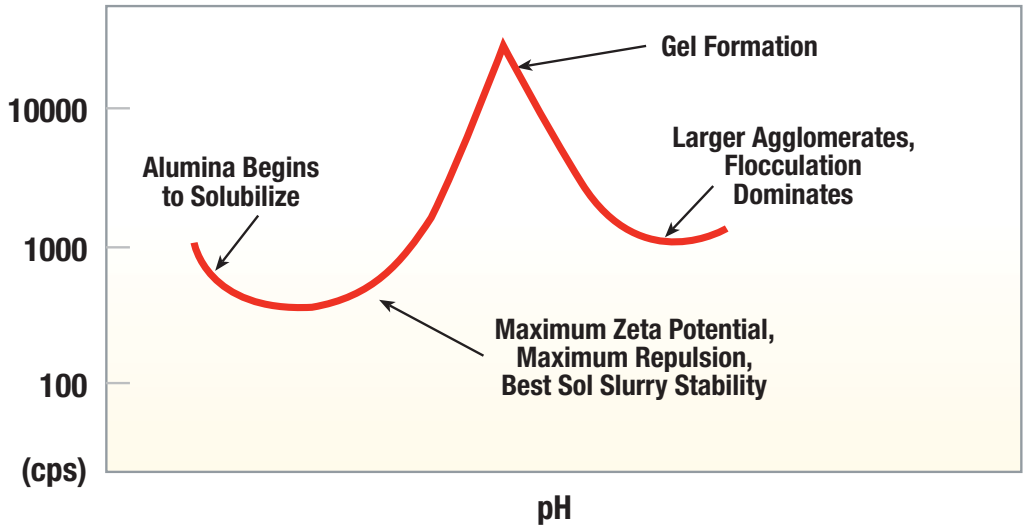




Slurry Preparation for Polishing and Surface Coating Applications

Applications for Versal aluminas include abrasives, chemical mechanical polishing slurries and coatings of an alumina film onto various substrates and surfaces. The figure below approximates a viscosity versus pH curve for a 5% alumina suspension of V-700. System pH, solids loading, particle size and shape, and surface charge all have effects on the rheological properties of an alumina slurry. At a neutral pH (pH 7.0), where alumina has a slight positive charge, aqueous slurries exist as relatively viscous systems. Increasing acidity or basicity from the neutral point dramatically affects viscosity. As an aqueous alumina system becomes more basic, the particle surface charge decreases and passes through a zero point where neither anions, nor cations are preferentially absorbed. Near pH 9.0 the degree of flocculation is maximized and the slurry viscosity passes through a minimum. Starting again with a neutral system, as acidity is increased, individual particles gain a more positive charge and the outer ionic layer is diminished. The smaller effective particles exhibit strong repulsion from each other resulting in a more fluid (lower viscosity) system. Further acidification below pH of about 3.0 causes the alumina to be solubilized. System viscosities begin to increase in these cases due to highly charged alumina polymers. In a typical preparation, an aqueous alumina slurry is typically acidified to a pH value 3.5-4.0 for minimum viscosity and maximum stability.

Viscosity pH Curve of Versal Products



UOP's Versal alumina family of high performance powders offers a broad spectrum of features designed to meet your alumina needs. Use the summary information below to determine what features of UOP's Versal product line best suit your application.

V-250

- Highest macropore volume
- Most resistant to high temperature sintering
- Most resistant to acid attack
- Low density
- Low dispersibility
- Highest friability particles in calcined phase

Easiest to Deagglomerate
A "Softer" (Polishing) Abrasive

V-700

- Lower macropore volume
- Low conversion temperatures for calcined alumina phases
- High dispersibility
- Mid range density
- Mid range friability of calcined phases

Combines Ease of Deagglomeration and Low Temperature Alpha ConversionA "Moderate" (Polishing) Abrasive

Bayerite Alumina

- High density
- Crystalline beta trihydrate
- Non-dispersible alumina
- Calcines to high surface area eta or theta alumina
- More acidic for catalysis

New to the Abrasives Industry

Gamma Alumina

- Derived from psuedoboehmite aluminas
- Tailored surface area, porosity, friability and hardness
- Three commercial products with varying density and porosity

Low Temperature Calcined Aluminas

Alpha Alumina

- Derived from Versal pseudoboehmite and bayerite aluminas
- Coral-like structure with high friability index
- Can be custom manufactured to a variety of specifications
- Prototype available at 8m^2/g surface area

High Temperature Calcined Aluminas

UOP can tailor aluminas in a variety of phases to fit specific surface area, porosity, friability and hardness requirements. These come in a variety of phases, such as pseudoboehmite and bayerite as well as higher temperature structures including gamma, theta and alpha. Please contact your nearest representative for further information about UOP Versal aluminas.

Find out more

If you are interested in learning more about our UOP adsorbents please contact your UOP representative or visit us online at www.uop.com

RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

UOP LLC, A Honeywell Company
25 East Algonquin Road
Des Plaines, IL 60017-5017, U.S.A.
Tel: +1-847-391-2000
www.uop.com

UOP5502
April, 2012
Printed in U.S.A.

UOP
A Honeywell Company