

1985 5

MACK PUBLISHING COPMANY Easton, Pennsylvania 18042



ensive adsorption. This is a consequence of the multiple hor groups. It is not probable that random thermally uced fluctuations would remove all anchor groups simuleously, even if the individual anchor group interacts with y4 or 5 kT energy. Many anchor groups may be attached he loop section of the molecule and cannot adsorb at the le interface. However, they have the potential of adsing at the interface of a neighboring solid particle.

he nature of the train-loop configuration of adsorbed mers causes the amount of polymer adsorbed per unit of acce area to increase extremely rapidly with increase in mer concentration until the surface coverage of the solid early complete. Above this plateau level further adsorpmay be negligible. The adsorption often is nearly irrelible, very little being removed by repeated washing.

s polymer adsorbs, the free energy of interaction between hboring loops becomes strong enough to arrest adsorption. good solvent this interaction is stronger than in a poor ent; therefore, the adsorbed layer will contain more mer when the adsorption is from a poor solvent. Concey, in a good solvent long loops tend to cause the polymer esorb because of the large free energy of interaction of mer loops in close proximity. Similarly, the configuration he molecule and the extension of the loops are dependent olvent quality. Loops in a poor solvent tend to coil and stend less distance from the interface than those in a good ent. Again the controlling factor is the magnitude of the raction of neighboring loops.

licles in Liquid Systems

he behavior of particles dispersed in a liquid medium is ect to essentially the same forces as those described for ders although the results can be different due to the ence of the liquid. For example, as will be seen, the rical forces in aqueous media between particles can play are important role than in powders under certain condise.

ffect of Charges—A solid particle or a droplet of an iscible liquid may be electrically charged because an exof ions of one sign may be present at the interface. The ge-conferring ions may be a constituent of the particle f, impurity ions from the external-phase liquid, or surnitions preferentially adsorbed at the interface.

he particle charge gives rise to a surface potential, ψ_0 , at surface of the particle (see Fig 21-13). The potential will to zero at some distance away from the surface depending se concentration of the counter-ions in the external-phase. The region in which the influence of the surface charge preciable is called the electrical double-layer region.

ne double layer may be visualized as being made up of two s. The specific adsorption of counter-ions in the Stern

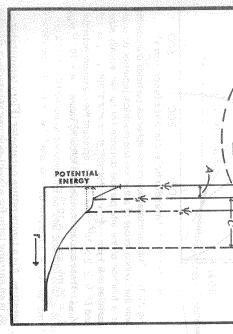


Fig 21-13. The electrical double layer and the symbols used to describe the potential at various points. A: The Stern layer, B: the plane of shear, and C: the sphere of influence of the diffuse double layer.

Layer comprises the first part, the thickness of which is of the order of ionic dimensions. The potential drop across this region is $\psi_0 - \psi_b$. The second part is called the diffuse double layer across which the potential drop is ψ_b . The thickness of the diffuse double layer is given by the Debye-Hückel quantity $1/\kappa$.

$$/\kappa = \left(\frac{\epsilon kT}{4\pi e^2 \Sigma n_i z_i^2}\right)^{1/2} \tag{19}$$

where ϵ is the dielectric constant in the diffuse double-layer region, k is the Boltzmann constant, T is the absolute temperature, e is the electronic charge, n_i is the bulk concentration of ion i, and z_i is its valence.

According to Eq. 19 a 1% aqueous sodium chloride solution at room temperature gives $1/\kappa = 8$ Å, a 0.01% solution gives $1/\kappa = 80$ Å, a $1 \times 10^{-4\%}$ solution gives $1/\kappa = 800$ Å, etc. These calculations show that the electrical influence among particles in aqueous media is relatively short-range compared to that involving powder particles which, as predicted by Eqs 3 and 4, extend to distances of the order of particle dimensions.

In nonpolar media n, the bulk ionic concentration, is usually very small. Therefore, $1/\kappa$ values of the order of centimeters are sometimes encountered, and in such cases the distances of electrical influence approach those encountered in powders. This frequently leads to the "electrostatic" problems in such systems. Antistatic agents are helpful in these situations by reducing $1/\kappa$ and by relieving the buildup of charge.

Eq 19 also shows that polyvalent counterions are much more effective than monovalent ions in reducing the double-layer thickness. A 2-2 electrolyte is about four times more

compared to the size of the adsorbed surfactant molec cles at a close distance where repulsive forces arise v molecules are squeezed together and/or desorbed.

effective than a 1–1 electrolyte in reducing the ble-layer thickness.

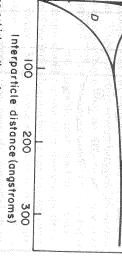
7 of a Potential — When a charged narticle si

Ideal Potential—When a charged particle styliquid is placed in an electrical field, it will might he electrode with the opposite charge. The ion Layer and the bound solvent molecules are also with the particle. Thus, the plane of shear (see very close to the Stern Layer but slightly farth the particle surface. While the exact relation the zeta potential, ψ_z , and ψ_b is not clear, it is a posed that ψ_b and ψ_z are of the same order of m latter being slightly smaller. If, in addition, ψ_0 mV) and there is little special counterion-bine at the interface, the zeta potential will also reflece and the changes in it. The surface potential, ψ the surface charge density, the number of characa, by the Gouy-Chapman diffuse electrical theory.

As will be seen in the next section, when elect is present, the flocculation behavior of sus emulsions strongly depends upon the surface particles which is reflected in the magnitude of when ψ_z is of the order of 25 mV or less, the sykinetically unstable to flocculation and aggraphs alescence may take place.

Particle Interactions in Liquids—Accordance theory of the stability of lyophobic colloids (par media) a number of forces are at play in deriver interaction forces is helpful in understanding interaction forces is helpful in understanding in process as well as aggregation and coalescence dispersed particles. At relatively large distance (\$10 Å) the primary forces are the London distinction and the electrical repulsive forces the interaction of the diffuse double layers of The electrolyte flocculation behavior of sustemulsions is frequently attributed to the interactical and the dispersion forces.

Other forces of repulsion should also be conticularly at close distances of approach between These are the repulsive contributions due to molecules themselves, arising from steric hind 21-14). Particles at very close distances of application apart by this mechanism and by the results adsorbed agents from being displaced (desorinterface. When surfactant desorption is involved one against those same forces that are responsed.



ne net interaction of two spherical particles considering in forces of attraction and electrical repulsion (kt units) of the interparticle distance (Å) for two equally sized μ m. A: $\kappa = 2 \times 10^6$, B: $\kappa = 4 \times 10^6$, C: $\kappa = 10^7$, \times 10⁷. The peaks represent the maximum potential, calculations used the following values: $A = 10^{-13}$ ergs, and $\lambda = 10^{-5}$ cm.

a temperature parameter (Flory temperature), py term for solvent-polymer interaction, δ is the he adsorbed polymer layer, r is the radius of the \overline{V}_S is the volume fraction of adsorbed polymer region, and \overline{V}_1 is the molecular volume of the ules. When the interparticle distance, H, is less greater than 0; for $H \ge 2\delta$, $V_S = 0$. For addies and information see references 5 to 14, at the apter.

raction—The net interaction of two spherical ven by,

$$V_{\text{total}} = V_A + V_R + V_S \tag{23}$$

us solution at higher concentrations of eleco increase with increasing particle size. energy is shown in Fig 21-16. The energy repulsion is almost completely eliminated and high salt concentrations ($\kappa = 10^7 \text{ to } 2 \times 10^7$, ca ple, could be of substantial depth for larger minimum, V_{\min} , which, although small in the curve at $H \simeq 150 \text{ Å}$. This minimum is called lecreases and a minimum develops in the pocentration is increased ($\kappa = 4 \times 10^6$, ca 0.10%) e maximum potential, $V_{
m max}$, is large, $\sim\!25\,kT$ positive for all distances beyond the first few ectrical repulsion dominates at most distances, vater. At low ionic strengths, where $1/\kappa$ is large qual size $(a_1 = a_2 = 0.1 \,\mu\text{m})$ at different ionic ulsion,* Fig 21-15 shows plots of $V_{
m total}$ for two only the London forces of attraction and the persists. The influence of particle size on the

rical calculations of the potential energy of repulsion, nergy of attraction, and of adsorbed polymer repulsion dix B of a communication by Schneider, Stavchansky, *I Pharm Ed 42*: 280, 1978).

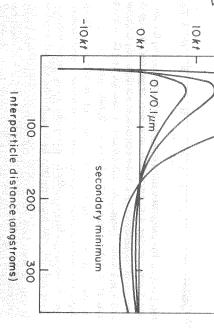


Fig 21-16. Influence of particle size on total potential energy of interaction. $A=5\times 10^{-13}$ erg, $\psi=25$ mV, and $\kappa=2\times 10^6$ cm⁻¹.

solvent quality are not independent factors. Also, changes of the dielectric constant of the liquid and of the sult of their effect on the double layer. The use of electroof adsorbed polymer, but the flocculation may not be the rebe justified for the charge distribution in the double layer. plane to be moved out from the particle surface; thus, a much phoretic mobility to determine the charge on the particle must earlier, electrolytes may produce flocculation in the presence The presence of other solvents may affect the Stern layer.⁶ ower value of the zeta potential will be observed than would present. The extending loops cause the hydrodynamic shear be viewed with apprehension when adsorbed polymer is the solution 30 or more angstroms, ie, $1/\kappa < \delta$. As suggested would have little influence when the polymer loops extend into bilized system,⁵ eg, a double layer of a few angstroms thickness have no significant effect on the stability of a sterically statrolytes, the double-layer thickness may be so small that it will

An anchor group on the polymer may form a weak bond and be an inefficient anchor.⁵ Such a polymer could desorb during interparticle collisions. This is designated "displacement flocculation." The kinetics of this should depend on the size of the adsorption interaction energy. Also, the addition of smaller molecules that could compete for and displace the polymer from the adsorption sites would be a controlling factor for the effectiveness of the polymer. One should be alert to these possibilities.

A possible mechanism of polymer action is that the polymer could prevent the particles from entering into the deep potential energy well illustrated in Fig 21-16, resulting from the combination of the van der Waals attraction and the double-layer repulsions. The relative thickness of the double layer and the adsorbed polymer layer would determine whether steric repulsion prevented entry into the primary minimum. If properly balanced, the net effect of the two terms could be to change the primary minimum to a shallow minimum by preventing closer approach of the particles.

charged micelles. The dissolution rates are en manyfold in the presence of high electrolyte concent neutralizing amines and quaternary ammonium complement, the dissolution of cholesterol gallstones by perfect of the gallbladder with sodium cholate micellar solution the gallbladder with sodium cholate micellar solutions.

Toccuration Kinetics

Rapid Flocculation—In the absence of any rebarrier ($V_{\text{Total}} = 0$) and when it is controlled only by Bi motion diffusion, the flocculation rate of a monodisuspension is given by the Smoluchowski equation:

$$\frac{dN}{dt} = -4\pi DRN^2$$

where dN/dt is the disappearance rate of particles/cc, distance between the centers of the two particles in c N is the number of particles per mL, and D is the discoefficient. Eq 24 shows that the flocculation reaction molecular, the rate being proportional to the square particle concentration. If D is replaced by the E relation, $D = kT/6\pi\eta a$, and R = 2a, the Smoluchow constant for rapid flocculation is predicted by

$$K = 4\pi DR = \frac{4kT}{3\eta}$$

The time, $t_{1/2}$, required to reduce the total number of p to one-half the original number is given by

$$t_{1/2} = \frac{3\eta}{4kTN}$$

Here, η is the viscosity of the liquid medium and Λ initial concentration of particles (number of partic cc).

It is well known that agitation promotes flocculation appears to have little influence in the initial stages flocculation. In the simplest case (see Fig 21-17) consi particles in a laminar shear field with a velocity grad so that other particles are swept into the sphere of ac a central particle. The increase in the flocculation evident when the collisions caused by the movement liquid and by Brownian motion are added. By compar probability of laminar shear collision, J, with the prob of Brownian collision, I,

$$J/I = \frac{\eta a^3 g}{2kT}$$

the measure of the relative contributions of these ty motions to flocculation is found. Table VIII shows t small colloidal particles collisions caused by agitation compared to those caused by Brownian motion unless thear gradient is very high. It also shows the transity tween the region of colloidal dispersion, where Bro



um; Ε: 0.1/0.5 μm; F: 0.1/0.1 μm. ergs. A: 1.0/1.0 \(\mu\mathrm{m}\); B: 0.5/1.0 \(\mu\mathrm{m}\); C: 0.5/0.5 itration of a 1–1 electrolyte in solution. ψ_0 is 25 my es with themselves and with larger particles as a calculated rates of aggregation of 0.1 μ m, 0.5 μ m

$$\frac{G_{12}}{N_1 N_2} = \frac{2kT}{3\eta W_{12}} \left(\frac{1}{a_1} + \frac{1}{a_2} \right) (a_1 + a_2) \tag{30}$$

of magnitude greater than that for two 0.5- μm s with themselves or larger particles may be t the rate of aggregation (or coalescence) of les with each other or with large particles. 2 to 4×10^6 for $\psi_0 \simeq 25$ mV, it can be seen eference for the aggregation (or coalescence) low electrolyte concentration may markedly

estable foreign

particle size, expressed mathematically as in part because of the recognized variation of uspensions may undergo dissolution and re-

$$S = S_{\infty} \exp \left(\frac{2\gamma M}{v \rho R T} \right) \tag{31}$$

ery fine particles of certain substances. s encountered in preparing and stabilizing mer. This difference in solubility explains olve and for coarse crystals to grow at the exe crystal, hence the tendency for very fine m, S values become appreciably greater than fM, γ , and ρ . It is evident that with particles article size effects on the solubility for readifferent crystal faces. Table IX shows the se the particles are not spheres, and γ values nly approximations can be obtained with this m, R is the gas constant, and T is the absolute nt, ρ is the density, γ is the crystal/solvent of an infinitely large crystal $(r = \infty)$, M is the olubility of a spherical crystal of radius r, S...

X—Solubility of Small Particles

						ч
	The second second	C) 1	week, .	- comp		
				-	0.1	200
				-	/ · 1 · :	6
	200 1 10 200					G
	2			1.00	100	v
	£					
				1 1 1 1 1 1	100	
	1760 11			8	11.	
					-015 E 10	
	in a support of the second		1.57	1 3.		æ
	100		44.7		. 1	٩
	Barton and State				201	á
	1000			8	- C	۹
	1 27					B
						ò
	100			E 1.7		a
	E. P. LOWER ST.					4
			- 1	F		٩
			1.0		100	9
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				200	VS.
	1 - 2 - 3 - 1 - 1 - 1 - 1				11 .	At
	1000		4.4			ø
	1 - 1 Dog - 1 mg					ú
	The State of Co.					×
	11、15年中央出版。				- 5	
	Livinia 187				100	ð
	particular for the		10.1		1	×
	1.000				10 to 1	60
516.7						
					N 1 1	ä
157.53	and the second				100	ą.
					3.555	2
			- 3.1		10.00	Œ
124			- 5			
-437						2
						Ω
1723						~
1244					100	ä
		1177			: I .	
5						w
32.3	A Table Park	. 01	~		1.14	
200	Joseph Jonesh	hanced , re	-1			u
			- 60			€
110	-	medi 7	45			
	100	5	12.			т
200	· Cool	1/2 .	. 31			ø
	100.00	6	100	80	- 1 C	88
	7-	7	30.00	(V)	化化量 子	ø
	42	(J)			86 5	W
	· (6) 0	0			100 E 1	щ
1.1	- W. C. B	8				é
	1.01 S. 1.001 S.		- 1			CARCAR CARCACA CARCACACA CARCACACACACACA
	u .		177			8,
- 1					4.10	*
100						
8						
. 1			- 1			
			115		S-1 1	
0.08						
			1		- 1	
			- 1		1.	
			200			
			1		- I	
100			1			
5.5			- (0.1	
100			3			
			1			
1.1						

 gs/cm^2 ; $\rho = 1$

Suspensions

nition is extended to include these products. pensing by the addition of an appropriate vehicle, this defiin a dry form, to be placed in suspension at the time of disdosage form. Since some products are occasionally prepared ophthalmically in the eye. They are an important class of given by the oral route, injected intramusculary or subcutapended in a liquid medium. Suspension dosage forms are dispersion containing finely divided insoluble material susneously, applied to the skin in topical preparations, and used A pharmaceutical suspension may be defined as a coarse

ally, the product should be easy to pour, pleasant to take, and with a minimum effort on the part of the patient. Additionthat they do not settle rapidly in the container. However, in should meet. The dispersed particles should be of such a size form a hard cake. Rather, it must be capable of redispersion the event that sedimentation occurs, the sediment must not resistant to microbial attack. There are certain criteria that a well-formulated suspension

settling of the dispersed particles, and (3) caking of these of the following discussion will deal with the factors that inare (1) adequate dispersion of the particles in the vehicle, (2) fluence these processes and the ways in which they can be particles in the sediment so as to resist redispersion. Much The three major problem areas associated with suspensions

nterfacial Properties

relates to an increase in the free energy of the surface as the of whether the dispersed phase is solid or liquid. The first the surface of the dispersed particles. particles, two factors must be taken into account, regardless particle size is reduced and the specific surface increased The second deals with the presence of an electrical charge on When considering the interfacial properties of dispersed

energy is related to the increase in surface area produced when dium, is an attempt by the particles to reduce the excess sur are reduced in size, they tend to agglomerate or stick together the particle size is decreased. It may be expressed as fol face free energy of the system. The increase in surface free This clumping, which can occur in either air or a liquid me-Surface Free Energy-When solid and liquid materials

 $\Delta F = \gamma \Delta A$

and the dispersion medium. The smaller ΔF is, the more the increase in surface area in cm², and γ is the interfacial where ΔF is the increase in surface free energy in ergs, ΔA is and the vehicle, thereby reducing the interfacial tension. agent which is adsorbed at the interface between the particle reduction in ΔF often is effected by the addition of a wetting thermodynamically stable is the suspension of particles. A tension, in dynes/cm, between the dispersed particle or droplet

> settle. Such a sediment can be extremely difficult t cake at the bottom of the container when they eve flocculated, and settle relatively slowly, they can form Unfortunately, while the particles remain dispersed

opposing forces determines whether or not two parti in a liquid medium. The balance achieved betwee both attractive and repulsive forces exist between p at a certain distance of separation. proaching each other actually make contact or are r Surface Potential—As discussed earlier in this

applied to suspensions and emulsions.9

Flocculation and Deflocculation—Zeta potent phobic colloids, the theories developed in this area ha potentials in dispersed systems has been carried out While much of the theoretical work on electrical

gether by random motion or agitation, deflocculated p are said to be deflocculated. Even when brought c a measurable indication of the potential existing at the resist collision due to their high surface potential. repulsive forces between two particles exceed the at of a particle. When ψ_z is relatively high (25 mV or m London forces. Accordingly, the particles are disper

aggregates, termed flocs. Such a system is said to be particles may approach each other more closely and for electrical forces of repulsion are lowered sufficiently is opposite in sign to that on the particle leads to a pro forces of attraction predominate. Under these condit lowering of ψ_z . At some concentration of the added The addition of a preferentially adsorbed ion whose

gation brought about by chemical bridging; aggrega cesses, irrespective of mechanism. volving a reduction of repulsive potential at the doub chapter the term flocculation is used for all aggregat tential energy curve of two interacting particles and lation as aggregation in the secondary minimum of is referred to as coagulation. Other workers regard ation as aggregation in the primary minimum. In the Some workers restrict the term flocculation to th

ences between suspensions of flocculated and defloc particles are presented in Table X. is negative rather than positive. Some of the major occur again. The only difference from the starting sy in the opposite direction. Thus, the adsorption of ani this has achieved the required magnitude, deflocculat tually generate a net negative charge on the particles. positively charged deflocculated particles in suspens the above process, if the zeta potential increases suf that the net charge on the particles in their deflocculat lead to flocculation. The addition of more anions ca The continued addition of the flocculating agent car

of sediment should encompass the volume of the

values are 0.33 µm for latex particles and 0.017 rticles. Micelles and small phospholipid vesttle unless they are subjected to centrifuga-

tions in a pharmaceutical suspension are not d with those laid down for Stokes' law, Eq 33 factors that can be expected to influence the Thus, sedimentation velocity will be reduced he particle size, provided the particles are kept red state. The rate of sedimentation will be an in of the viscosity of the dispersion medium, ugh a viscosity is undesirable, especially if the dium is Newtonian rather than shear-thinning 2), since it then becomes difficult to redisperse i has settled. It also may be inconvenient to us suspension from its container.

Stokes' law, the rate of sedimentation will be difference in the densities (ρ_1 and ρ_2) of the icles and the continuous phase can be described arrely possible in practice, and will not be ser.

Movement—When the size of particles imentation is reduced to approximately $2 \mu m$, nian movement is observed and the rate of departs markedly from the theoretical prekes' law. The actual size at which Brownian mes significant depends on the density of the las the viscosity of the dispersion medium. e lower limit of the coarse-size range, the dismay remain suspended for a prolonged period his phenomenon.

occulation—In a deflocculated system conbution of particle sizes, the larger particles faster than the smaller particles. The very remain suspended for a considerable length he result that no distinct boundary is formed pernatant and the sediment. Even when a mes discernible, the supernatant remains

me system is flocculated (in a manner to be two effects are immediately apparent. First, of all together so that a distinct boundary benent and the supernatant is readily observed; ernatant is clear, showing that the very fine ernatant is clear, showing that the very fine een incorporated into the flocs. The initial officculated systems is determined by the size the porosity of the aggregated mass. Under nees it is perhaps better to use the term subthan sedimentation.

Quantitative Expressions of Sedimentation and Flocculation

Frequently, the pharmacist needs to assess a formulation in terms of the amount of flocculation in the suspension and to compare this with that found in other formulations. The two parameters commonly used for this purpose are outlined below.

Sedimentation Volume.—The sedimentation volume, F, is the ratio of the equilibrium volume of the sediment, V_u , to the total volume of the suspension, V_0 . Thus,

$$F = V_u/V_0 \tag{36}$$

As the volume of suspension which appears occupied by the sediment increases, the value of F, which normally ranges from nearly 0 to 1, increases. In the system where F=0.75, for example, 75% of the total volume in the container is apparently occupied by the loose, porous flocs forming the sediment. This is illustrated in Fig 21-19. Obviously, in a particular suspension, if F can be made to approach closer to unity, the product becomes more acceptable, since the volume of supernatant (undoubtedly regarded as unsightly) is being progressively reduced. When F=1, no sediment is apparent even though the system is flocculated. This is the ideal suspension for, under these conditions, no sedimentation will occur. Caking also will be absent. Furthermore, the suspension is esthetically pleasing, there being no visible, clear supernatant.

Degree of Flocculation—A better parameter for comparing flocculated systems is the *degree of flocculation*, β , which relates the sedimentation volume of the flocculated suspension, F, to the sedimentation volume of the suspension when deflocculated, F_{∞} . It is expressed as

$$= F/F_{\infty} \tag{37}$$

The degree of flocculation is, therefore, an expression of the increased sediment volume resulting from flocculation. If, for example, β has a value of 5.0 (Fig 21-19), this means that the volume of sediment in the flocculated system is five times that in the deflocculated state. The flocs are quite porous and the desirable scaffold-like structure is present. If a second flocculated formulation results in a value for β of say 6.5, this latter suspension obviously is preferred, if the aim is to produce as flocculated a product as possible. As the degree of flocculation in the system decreases, β approaches unity, the theoretical minimum value.

Formulation of Suspensions

The formulation of a suspension possessing optimal physical stability depends on whether the particles in suspension are to be flocculated or to remain deflocculated. One approach involves use of a structured vehicle to keep deflocculated particles in suspension; a second depends on controlled flocculation as a means of preventing cake formation. A third,

Deflocculated
suspension
in structured vehicle
as final product

Flocculated
structured vehicle
as final product

Flocculated
suspension
in structured vehicle
suspension
in structured vehicle

Fig 21-20. Alternative approaches to the formulation of s sions.

a combination of the two previous methods, result product with optimum stability. The various schem illustrated in Fig 21-20.

Dispersion of Particles—The dispersion step has discussed earlier in this chapter. Surface-active a commonly are used as wetting agents; maximum efficies obtained when the HLB value lies within the range of A concentrated solution of the wetting agent in the value has be used to prepare a slurry of the powder; this is downth the required amount of vehicle. Alcohol and glymay be used sometimes in the initial stages to disperparticles, thereby allowing the vehicle to penetrate the pmass.

Only the minimum amount of wetting agent should be compatible with producing an adequate dispersion particles. Excessive amounts may lead to foaming or an undesirable taste or odor to the product. Invaria a result of wetting, the dispersed particles in the vehi deflocculated.

Structured Vehicles—Structured vehicles are genaqueous solutions of polymeric materials, such as the l colloids, which are usually negatively charged in aqueolution. Typical examples are methylcellulose, can methylcellulose, acacia, bentonite, and Carbopol. The centration employed will depend on the consistency d for the suspension which, in turn, will relate to the sidensity of the suspended particles. They function acosity-imparting suspending agents and, as such, redurate of sedimentation of dispersed particles, in according the suspending agents and as such, redurate of sedimentation of dispersed particles, in according the suspending agents used in practice are non-Newtonia. The rheological properties of suspending agents are

sidered elsewhere (Chapter 22). Ideally, these form doplastic or plastic systems which undergo shear-thii Some degree of thixotropy is also desirable. Non-New materials of this type are preferred over Newtonian sy because, if the particles eventually settle to the bottom container, their redispersion is facilitated by the v thinning when shaken. When the shaking is discont the vehicle regains its original consistency and the redisparticles are held suspended. This process of redispersionitated by a shear-thinning vehicle, presupposes the

DOCKET

Explore Litigation Insights



Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time** alerts and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

