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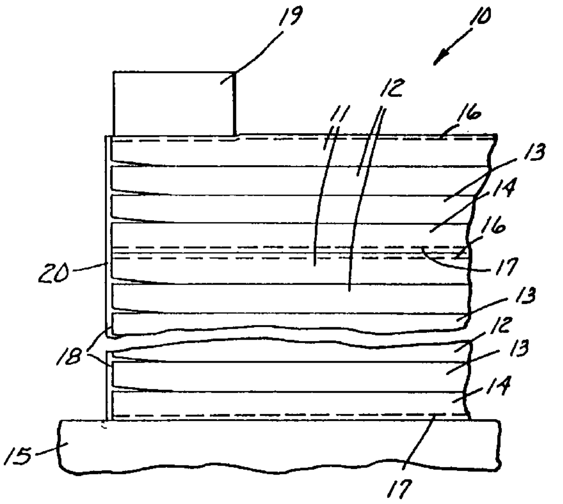
(54) Colloids to increase coefficient of friction in carbonless paper pad coatings.

(57) A composition suitable for use as a pad-coat or release coating for carbonless paper constructions, the composition containing about : (a) 0.1-10.0 weight percent inorganic colloid having a particle size in the range of about 1-125 nm ; (b) 0.1-5.0 weight percent abherent material ; (c) 60.0-99.9 weight percent water ; and (d) 0-25 weight percent binder, based upon the total weight of the coating composition. In a preferred embodiment, colloidal silica is utilized. Also disclosed is a carbonless paper construction with at least a portion of at least one outer surface having the inventive pad-coat or release coating applied thereto.

The incorporation of inorganic colloidal particles into carbonless paper pad-coats results in an increase in the coefficient of friction of the pad coated surface ; increase in toner adhesion and ink receptivity of the pad-coated surface ; promotes uniform feeding of carbonless paper sheets into photocopiers and printing presses by reducing misfeeds and double feeds ; and reduces feeder induced smudging. It does this without loss of the abhesive release effect provided by the pad-coat and without loss of the fan-out ability to produce form-sets.



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BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to pad coats or release coatings for carbonless copy papers and in particular, this invention relates to pad coats or release coatings which contain, in part, an inorganic colloid and an abherent. This invention also relates to carbonless paper constructions which are at least partially coated with the inventive pad coat or release coating.

Description of the Related Art

Carbonless impact marking papers for the transfer of images, (i.e., carbonless copy papers) are papers which are capable of producing an image upon application of pressure. Products employing this chemistry generally contain at least two substrates (for example, two sheets of paper) and involve coating one reactant, known as a color-former, on one substrate, and the other reactant, known as a developer, on another "mating" substrate. One surface, or side, of each substrate is coated with one of the two primary reactants. The two substrates are often referred to as a donor sheet and a receptor sheet. Means for preventing the reacting of the two until intended (i.e., until activating pressure is applied) are also provided. This is typically accomplished by encapsulation of one of the reactants. Preferably, a fill solution of the color-forming compound(s) in a hydrophobic solvent is encapsulated or contained in microcapsules and is coated on the back side of one sheet of paper to form a donor sheet. This is then mated with a receptor sheet coated with a developer or reactant for the color-forming compound. The microcapsules serve the purpose of isolating the reactants from one another and preventing reaction. Once activating pressure is applied to the uncoated surface of the donor sheet, such as from a stylus or business-machine key, the two substrates come into contact under sufficient pressure so that the capsules rupture (i.e., those capsules corresponding to the pattern of applied pressure) and the solution of encapsulated color-former is released and transferred from the donor sheet to the receptor sheet. On the receptor sheet, a reaction between the previously separated reactants occurs. Since the color-former and the developer form a deeply colored image when reacted, an image forms on the receptor sheet. In general, the resulting reaction will, of course, form a colored image corresponding to the path traveled by the stylus or the pattern of pressure provided by the stylus or key. The term "activating pressure" includes, but is not limited to, pressure applied by hand with a stylus or pressure applied by a business machine key (for example, a typewriter key); and the term "encapsulation" and "encapsulated compounds" refer to microcapsules enclosing a fill material.

A preferred construction contains an encapsulated color-former dissolved in appropriate hydrophobic solvent(s) within microcapsules and coated with a suitable binder onto a back side of the donor sheet, sometimes referred to as a "coated back" (CB) sheet. A developer, also optionally in a suitable binder such as a starch or latex, is coated onto the front side of the receptor sheet sometimes referred to as a "coated front" (CF) sheet. The term "suitable binder" refers to a material, such as starch or latex, that allows for dispersion of the reactants in a coating on a substrate. Each CB coating contains rupturable capsules which, when ruptured, release reagents to produce a color-changing reaction at the adjacent CF coating. The preparation of such carbonless sheets is disclosed by Gale W. Matson in U.S. Patent Nos. 3,516,846 and 3,516,941, incorporated herein by reference.

A wide variety of processes exist by which microcapsules can be manufactured. These varied processes provide different techniques for producing capsules of varying sizes, alternative materials for the composition of the capsule shell, and various different functional materials within the shell. Some of these various processes are disclosed in U.S. Patent Nos. 2,800,427; 2,800,458; 3,416,441; 3,429,827; 3,516,846; 4,087,376; 4,100,103; 4,909,605; and British Patent Specification Nos. 950,443 and 1,046,409. A wide variety of capsule materials can be used in making the capsule shells, including gelatin and synthetic polymeric materials. A popular material for shell formation is the product of the polymerization reaction between urea and formaldehyde, or between melamine and formaldehyde, or the polycondensation products of monomeric or low molecular weight polymers of dimethylolurea or methylolated urea with aldehydes. A variety of capsule forming materials are disclosed, for example, in U.S. Patent Nos. 2,800,458; 3,429,827; 3,516,846, 4,087,376; 4,100,103 and British Patent Specification Nos. 1,046,409; 2,006,709 and 2,062,570.

As stated previously, in imaging, the two sheets are positioned such that the back side of the donor sheet faces the developer coating on the front side of the receptor sheet. In many applications the uncoated surface of the donor (CB) sheet contains a form of some type and the activating pressure is generated by means of a pen or other writing instrument used in filling out the form. Thus, the image appearing on the receptor (CF) sheet is a copy of the image applied to the top sheet.

Constructions containing a first substrate surface, on which is coated the encapsulated color-former, and a second substrate surface, on which is coated a developer, are often prepared. The coated first substrate surface is positioned within the construction in contact with the coated second substrate surface. Such a construction is known as a "set" or a "form-set" construction.

Substrates, with one surface, on which is coated the encapsulated color-former, and a second, opposite surface, on which is coated a developer, can be placed between the CF and CB sheets in a construction involving a plurality of substrates. Such sheets are generally referred to herein as "CFB" sheets (i.e., coated front and back sheets). Of course, each side including color-former thereon should be placed in juxtaposition with a sheet having developer thereon. CFB sheets are also typically used in form-sets. In some applications, multiple CFB sheets have been used in form-sets. These contain several intermediate sheets, each having a developer coating on one side and a coating with capsules of color-former on the opposite side. Thus, the sheets in the form-set are sequenced in the order (from top to bottom) CB, CFB(s), and CF. This insures that in each form-set a color former and a color developer will be brought into contact when the microcapsules containing the color-forming material are ruptured by pressure.

An alternative to the use of CB, CF, and CFB sheet is the self-contained (SC), or autogenous, carbonless paper in which both the color-former and developer are applied to the same side of the sheet and/or are incorporated into the fiber lattice of the paper sheet.

Carbonless paper is widely used in the forms industry and carbonless paper forms have been printed in the past by conventional printing techniques such as offset printing, lithography, etc. With the advent of high speed electrophotographic copiers having dependable, high capacity collating systems and enhanced copy quality, there has been a movement to replace offset printing equipment located in print shops and large "quick-print" installations with electrophotographic copiers. For the successful use of carbonless papers in these copiers, compatibility of the carbonless paper with the machine is critical. For example, the base sheets upon which carbonless paper coatings are applied to form carbonless papers conventionally imaged via offset printing do not have sufficient stiffness or sufficient sensitivity to machine conditions for curl and moisture control to be handled in copier processors and sorters.

Carbonless paper is often used in the form of printed form-sets for preparing multiple copies of receipts, bills, and other business forms and form-sets are prepared by collating from 2 to 8 sheets. Form-sets are typically made by applying an adhesive to the edge of a stack of the carbonless paper. Each of the coated sheets in a form-set is somewhat porous and permits the adhesive to penetrate into the pores of the paper, such penetration being necessary to attain satisfactory adhesion of sheets within the form-set. Adhesives useful for edge-padding carbonless papers are described, for example, in U.S. Patent No. 5,079,068, the disclosure of which is incorporated herein by reference.

The adhesively bound papers are then "fanned-out" to separate into individual form-sets. To promote separation, carbonless copy paper form-sets often have a release coating (for example, a fluorocarbon or silicone coating) applied to at least one of the outer faces of each form-set. These coatings are often referred to as "pad coats." Pad coats function as an abhesive (or non-adhesive) to provide low adhesion properties to the outer faces of a form-set; act as a release agent for the edge-padding adhesive; and promote "fan-out properties" in edge padding to allow the adhesively edge-padded stack to "fan-out" or "fan-apart" and separate into individual form-sets upon fanning. Pad coats are also necessary to counteract curling that otherwise would result from stresses induced in the paper by the CB and CF functional coatings on the opposite surface of the sheet. The surface of the paper coated with capsules or developer may be referred to, respectively, as the CB and CF coated surface or as CB_{fc} and CF_{fc} representing the "functional coated surface" or "functional coated face" of the sheet.

The pad coat is applied to the front face of the capsule coated (CB) sheet and/or to the back face of the developer coated (CF) sheet. The term "CB_{pc}" refers to the front, pad-coated surface of the CB sheet. The term "CF_{pc}" refers to the back, pad-coated surface of the CF sheet. Pad coats are by nature low surface energy materials which operate by preventing wetting of the paper surface by the adhesive. Unfortunately, low surface energy, pad coated surfaces also lower the coefficient of friction of the sheet surface and is one cause of double or multiple sheet feeds and paper misfeeds. The low surface energy, pad-coated surface also reduces toner powder adhesion, resulting in low image density and poor toner anchorage to electrophotographically produced images on the pad coat surfaces. Because of differences in the fluorocarbon coatings, an adhesive that affords fan-apart edge-padding of a certain carbonless copy paper may not be operative with other carbonless copy papers manufactured by different companies.

"Fan-out" is a method of separating a stack or pad of multiple form-sets into individual sets. One method of "fanning-out" or "fanning-apart" a stack of collated sheets involves gripping the edge-padded end of the stack with one hand and the unpadded edge with the other and then bending the stack into a "U" shape. While holding the stack horizontally, the padded end is released and allowed to droop downward. This provides enough stress on the adhesive to separate the pad or stack into individual form-sets.

One problem encountered when preparing forms of carbonless paper either by printing or photocopying is low adhesion of ink or toner to the various surfaces of the carbonless paper sheets. Carbonless papers often must contain information such as contract terms or instructions printed onto various faces of the sheets. Thus, all sheet faces must be ink and/or toner receptive. As noted above, carbonless papers often have pad coats to promote fan-out properties of form-sets. However, these pad coats tend to decrease ink and toner receptivity of the pad coated surface, thus making ink and/or toner adhesion difficult. This results in low adhesion of toner powder to the pad coat surfaces and results in low density images.

Often carbonless paper is prepared and packaged in precollated form-sets. In one version, referred to as a "straight sequence form-set," the sheets are arranged in the order in which they will appear in the finished form. In these form-sets, the coated back (CB) is first in the form-set, the coated front sheet (CF) is last, and the required number of CFB sheets are in between. Alternatively, the paper may be prepared and packaged in precollated form-sets referred to as "reverse sequence form-sets," wherein sheets of various colors and surfaces are arranged opposite to their normal functional order. The coated front sheet (CF) is first in the form-set, the coated back sheet (CB) is last, and the required number of CFB sheets are in between. When sheets are arranged in this manner and are printed in a printer or copier which automatically reverses their sequence, they will end up in the delivery tray in the proper order for subsequent padding and data entry. The type of sequenced form-set used for a particular printing operation is a function of the printing machinery.

One problem frequently encountered when precollated carbonless papers are run in low and mid-volume electrophotographic equipment is multi-sheet feeds. One cause of multi-sheet feeds is non-uniform surface friction between CB, CF, and pad coated surfaces. CB and CF coatings tend to increase coefficient of friction ("c.o.f.") when compared to an uncoated base sheet, while pad coat formulations which contain low surface energy, non-adhesion promoting release materials such as fluorochemicals or silicones tend to decrease the coefficient of friction when compared to an uncoated base sheet. When a pad coated surface and the CB or CF coated surfaces are brought together, a large sheet-to-sheet coefficient of friction difference occurs. This surface arrangement happens frequently in both straight and reverse sequence precollated carbonless papers. Large sheet-to-sheet c.o.f. differences are known to interfere with sheet separation in friction type feed systems. Rather than just the top sheet advancing through the feed mechanism, there is a tendency for a second, adjacent sheet or for multiple sheets to advance and feed with the top sheet.

A second problem encountered when precollated carbonless papers are used in friction fed machines results from coefficient of friction mismatch of contacting surfaces and results in the development of dense, noticeable smudge marks on CF sheets. Smudging occurs when two or more carbonless paper sheets enter the feed mechanism together and is believed caused by inadvertent capsule rupture and transfer of color-former from CB to CF surface. This problem is particularly acute when the copier uses a pressure roller or belt for pick up and feeding the sheet into the copier. This problem was addressed by Beery who attributed the smudge to mechanical locking between the sheets due to the relatively high coefficient of friction between the sheet surfaces (see J. Beery, WO 89/04804). His solution was to modify the feed rollers in the machine to make them softer, so that the pressure exerted on the capsule coated surface was reduced and less pressure was placed over the areas of the sheet engaged by the feed mechanism. While photocopier modification by changing the configuration and hardness of the feeding system represents one solution, machine modification is often costly and requires cooperation of the machine manufacturer. It would be advantageous to decrease smudge mark formation without machine modification. A more desirable solution would be to modify the paper surface to machine operation to eliminate smudging.

In order for paper to function properly in a photocopier, a balance must be struck between the various properties that affect print quality and paper handling within the machine. These balances were discussed by Green in a paper on "Functional Paper Properties in Xerography" (see C. J. Green, *Tappi,* **1981**, *64(5)*, 79-81). He noted that print quality and paper handling are related to the smoothness, electrical resistivity, curl (sheet flatness), stiffness, moisture content, porosity, friction, finish, and wax pick of the paper and that very often the requirements for print quality conflict with those for paper handling. For example, smooth papers give better fix (toner adhesion), but rough papers give better feed properties and paper transport. He further states that: "In considering feeding reliability, the absolute level of paper to paper coefficient of friction is not as important as the variation between consecutive sheets. To prevent multiple feeds in ordinary friction feeders, the variation of coefficient of friction should be less than 0.1." This is easily achievable in xerographic papers. In carbonless papers, which have different coatings on their various surfaces, the coefficient of friction varies considerably from surface to surface. The pad coated surfaces (CB_{pc} and CF_{pc}) have coefficients of friction of about 0.35, while the functional surfaces (CB and CF) have coefficients of friction of about 0.55 to 0.65.

The use of colloidal silica to prevent skidding by increasing the coefficient of friction of linerboard was taught by Inoue and coworkers (M. Inoue, N. Gurnagul, and P. Aroca, *Tappi Journal* **1990,** *72(12),* 81-85). They related coefficient of friction with surface free energy and reported increased friction with use of colloidal silica and increase of surface energy from 26.8 dyne/cm to 39.8 dyne/cm.

C.H. Fletcher, Jr. discussed the use of colloidal silica as a paper frictionizer material in an article entitled "Anti-Skid Treatments Utilizing Colloidal Silica" (see C.H. Fletcher, *Tappi,* **1973**, *56(8),* 67-69). U.S. Patent No. 3,389,100 discloses the use of silica aerogel as an anti-skid agent in printing inks for cartons.

Recently, a pad coat for carbonless paper was disclosed in U.S. Patent No. 5,092,927 as comprising a binder, an aqueous pigment dispersion, and an abhesive component for promoting fan-out. This pad coat is purported to improve printability of the pad coated surface of the form-set. The pigments were chosen for their ink receptive properties and included calcium carbonate, clay, calcined clay, silicates, and alumina trihydrate. The enumerated pigment, Hydral 710B, has a particle size of 800 -1,000 nm. The patent did not disclose the use of colloidal size particles. A high shear mixer and optionally, a dispersing aid, were used to disperse the pigment particles.

EPO Publication No. 464,681 discloses a dye receiving element for thermal dye transfer in which the backside of the dye receiving element is composed of polyethylene oxide, submicron colloidal inorganic particles, and polymeric particles larger than the colloidal inorganic particles (1-10 μm in diameter). The purpose of the backside coating is to provide adequate friction for a pick roller to feed one sheet at a time from a supply tray, to minimize interactions between the front and back surfaces of sheets stacked in a supply tray, and to minimize sticking between dye donor element and the receiving element backside layer when the receiver element is accidently inserted into a thermal printer wrong side up. No requirements for printability, toning, or fan-out were mentioned or are required for this system.

Silicas and silicates are known and used as CF developers for leuco dyes in carbonless papers. For example, U.S. Patent No. 4,461,494 discloses the use of magnesium-aluminum silicate as a color developer for pressure sensitive carbonless copy paper. The material gives good color retention with freedom from greying or yellowing on storage. U.S. Patent No. 4,732,991 teaches the use of silica gel as a CF material useful as a developer for carbonless papers. Similarly, U.S. Patent No. 4,075,224 teaches the use of silica gels, acidic clays, or phenolic resins as developers for carbonless papers.

None of the above items make use of colloidal silica or colloids of other inorganic materials as frictionizing agents in pad-coats or release coatings of carbonless papers.

SUMMARY OF THE INVENTION

By the present invention, it has now been discovered that the incorporation of inorganic colloidal particles into carbonless paper pad-coats or release coatings results in an increase in the coefficient of friction of the pad coated surface and in toner adhesion and ink receptivity of the pad-coated surface; promotes uniform feeding of carbonless paper sheets into photocopiers and printing presses by reducing misfeeds and double feeds; and reduces feeder induced smudging. It does this without loss of the abhesive release effect provided by the pad-coat and without loss of the fan-out ability to produce form-sets.

Accordingly, the present invention provides a composition suitable for use as a pad-coat or release coating for carbonless papers, the composition consisting essentially of about: 0.1-10 weight percent inorganic colloid having a particle size in the range of about 1-125 nm; 0.01-2.5 weight percent abhesive material; and 65.0-99.9 weight percent water; and 0-25 weight percent binder, based upon the total weight of the coating composition. If desired, the composition may further contain a pH adjuster, a defoamer, an optical brightener, and the like.

The present invention further provides a carbonless paper construction having a pad-coat or release coating applied over at least a portion of at least one outer surface of the carbonless paper construction. The pad coat or release coating consists essentially of about: 2.0-95.0 weight percent inorganic colloid having a particle size in the range of 1-125 nm; 2.0-50.0 weight percent abhesive; and 0-95.0 weight percent binder, based upon the total dry weight of the coating composition. Such inventive carbonless constructions are particularly suitable for use in printing and electrophotographic applications.

Other aspects, advantages, and benefits of the present invention are apparent from the detailed description, examples, and claims.

DESCRIPTION OF THE DRAWING

The invention may be more easily understood in reference to the drawing, the single Figure of which schematically indicates in cross section the edge-padding of a stack of form-sets of collated sheets of carbonless copy paper.

Shown in the drawing is a stack **10** of 4-part carbonless copy paper sheets including top CB sheets **11**, intermediate CFB sheets **12** and **13** and bottom CF sheet **14** resting on table **15**. Each CB coating contains rupturable microcapsules which when ruptured release reagents to produce a color-forming reaction at the adjacent CF coating.

The outer faces of the top CB sheets **11** and the bottom CF sheets **14** of each 4-part form-set have been treated with an abhesive release coating, **16** and **17**, of the present invention. A flat plate (not shown) can be used to afford a smooth edge **18** with a steel bar **19**. An edge-padding adhesive composition **20** has been applied to the edge of the stack and has flowed into the stack between the sheets of each form-set to produce a stack of adhesively edge-padded form-sets. The adhesive has not flowed into the stack between the sheets separating each form-set due to the abhesive release coating **16** and **17**.

DETAILED DESCRIPTION OF THE INVENTION

The pad coat or release coating composition of the present invention contains an inorganic colloid, an abhesive material, and water. If desired, the pad coat or release coating composition can also include a binder, a pH adjuster, a defoamer, an optical brightener, and the like.

In general, the inorganic colloid can be any inorganic colloid. Preferred inorganic colloids are silica, alumina, titania, zirconia, antimony pentoxide, or calcium carbonate. Most preferably, colloidal silica is utilized. As used herein, "colloid" means a state of subdivision of matter which comprises either single large molecules or aggregations of smaller molecules. Colloidal particles are of ultramicroscopic size and are dispersed.

The size range of colloidal particles generally are from about 1 to 125 nm; preferably, from about 1 to 100 nm; and more preferably, from about to 5 to 75 nm. In contrast to colloidal particles, the effective particle size for most pigments should be at least half the wavelength of light. For visible light this means the lower limit of the effective pigment particle size should be about 200-400 nm. Thus, the lower size limit of colorless inorganic pigment particles is usually considered to be about 200 nm (see Kirk-Othmer, "Encyclopedia of Chemical Technology", Volume 17, Wiley Interscience, New York, 1982, pages 788-838). However, pages 795 and 808 of the foregoing reference show colorless inorganic pigments to have particle sizes ranging from 150-100,000 nm (0.150-100 μm).

The size difference between colloids and pigment dispersions is also important in coating operations. Colloid compositions have lower viscosities and are stable in the dispersed phase. Pigment compositions tend to be viscous and require high shear agitation and/or suspending aids to maintain pigment dispersion in the coating solution.

Colloidal dispersions are transparent or translucent due to the minute particle size of the suspended colloidal materials. This contrasts with pigment particles which are added to impart color, whiteness, or opacity to solvents in which they are dispersed.

The inorganic colloid is generally present in the inventive pad-coat or release coating composition in an amount (based upon the total weight of the coating composition) of about 0.1 to 10.0 weight percent; preferably, about 0.2 to 5.0 weight percent; and most preferably, about 0.3 to 2.5 weight percent.

The inorganic colloid functions to impart roughness to the surface of the paper as well as to improve ink and toner receptivity. It is surprising that inorganic colloidal materials, which have a high surface area, do not interfere with the padding and fan-out promoting properties of the abhesive. It is further surprising that such small amounts of colloid can have a dramatic improvement in toner anchorage or fixation to the pad coated surfaces.

As noted above, the abhesive, material serves to prevent the padding adhesive from penetrating the sheets and is necessary to permit fan-out of the stack. Such abhesive materials include silicones, organic-silicone copolymers and blends, organic polymer coatings, waxes, fluorochemicals, and fluorosilicones.

Preferably the abhesive is a fluorinated compound. In general fluorochemical abhesive materials or compositions useful in this invention comprise fluorochemical compounds or polymers containing at least one fluoroaliphatic radical or group, R_f.

The fluoroaliphatic group R_f is a fluorinated stable, inert, preferably saturated, monovalent, non-aromatic aliphatic group. It can be straight chain, branched chain, or cyclic, or combinations thereof. R_f is preferably a fully fluorinated radical, but hydrogen or chlorine atoms can be present as substituents provided that not one atom of either is present for every two carbon atoms.

The R_f group has at least 3 carbon atoms, preferably 3 to 20 carbon atoms, and most preferably about 4 to 10 carbon atoms, and preferably contains about 40% to 70% fluorine by weight. The preferred R_f groups are fully or substantially fluorinated and more preferably are perfluorinated aliphatic groups of the formula -C_nF_{2n+1}.

Useful fluorochemical polymers containing R_f groups include copolymers of fluorochemical acrylate and/or methacrylate monomers with copolymerizable monomers, including fluorinated and fluorine free monomers, such as methyl methacrylate, butyl acrylate, octadecylmethacrylate, acrylate and methacrylate esters of poly(oxyalkylene)polyol oligomers and polymers.

Methods for the preparation of polymers containing appropriate pendant fluorinated aliphatic groups and examples of fluorinated compounds that will function as abhesive components in the pad coats described herein are described in U.S. Patent Nos. 3,574,791, 3,728,151, and 5,079,068, the disclosures of which are incorporated herein by reference.

Fluorinated abhesive materials useful in pad coats are sold by 3M company under the trade names of Scotchban Protector FC-808, FC-824, and FC-829. A preferred abhesive material is FC-829.

In addition to the fluoropolymer abhesive, a number of other materials may be used as to provide a low energy surface for the pad coat and prevent the padding adhesive from bonding the paper into blocks. U.S. Patent No. 4,962,072 teaches the use of a sizing agent to prevent adhesion. It discloses sizes of alkyl ketene dimer, alkenyl succinic anhydride, and polyurethane. Another abhesive is taught in WO 90/15719. It relies on the low surface energy of metal salts of long chain fatty acids and incorporates natural pigments to improve printability and ink receptivity of the release coating. Another widely used release material for abhesives well known in the art is a silicone polymer, i.e., a polysiloxane. One such material is taught in Canadian Patent No. 2,042,685.

Silicone polymers for use as abhesives are available from several commercial sources for example; SM 2800 (available from General Electric Company), X-27740 and X-27741 (available from Dow Corning), and PC 104 (available from Rhone-Poulenc). For a discussion of the chemistry of thermally cured silicone release agents see Eckberg, R.P., *TAPPI Journal,* **1987**, *70,* pp 152.155 *(Adv. Conv. Pkg. Technol. 3(4))*.

The present invention is not limited to the use of a fluorocarbon abhesive, but extends to other known abhesives such as those described above. In addition to the abhesive material, other components in the pad coat may effect the coefficient of friction, the adhesion of imaging materials such as toner powder deposited in electrophotograhic copiers, and fan-apart. To test other abhesives, a silicone polymer was chosen as a representative material and evaluated in various formulations.

The abherent material is generally present in the inventive pad coat or release coating in an amount (based upon the total weight of the composition) of about 0.01 to 2.5 weight percent; preferably, about 0.05 to 2.0 weight percent; and most preferably, about 0.1 to 1.0 weight percent.

The water content of the pad coat or release coating composition of the present invention (based upon the total weight of the composition) is generally in an amount in the range of about 65.0 to 99.9 weight percent; preferably, about 75.0 to 99.8 weight percent; and most preferably, about 85 to 99.6 weight percent.

When utilized, the binder serves the purpose of allowing attachment of the other components to the paper. A preferred binder is starch, but other binders such as polyvinyl alcohol (PVA) and styrene/butadiene latexes may be used. A corn starch available from Grain Processing Corporation (Muscatine, IA) under the name of GPC Oxidized Corn Starch has been found to work well in the present invention. Phosphated wheat starch may also be used. The binder material is generally present in the inventive pad coat or release coating in an amount (based upon the total weight of the composition) of 0.0 to about 25.0 weight percent; preferably, about 0 to about 20.0 weight percent; and most preferably, about 0 to about 10.0 weight percent.

The pad coat solution may require pH control prior to addition of the colloid. If necessary, the pH of the pad coat solution should be adjusted by addition of acid or base to bring it into a pH range in which the colloid is stable.

The inventive pad coat or release coating is applied over at least a portion of at least one outer surface of a carbonless paper construction. In this instance, the coating consists essentially of about 2.0-95.0 weight percent inorganic colloid having a particle size in the range of about 1-125 nm, and preferably, about 5-85.0 weight percent inorganic colloid; and about 2.0-50.0 weight percent abherent, and preferably about 3.0-40.0 weight percent abherent, based upon the total dry weight of the fluorinated abherent. When utilized, binder is present in an amount of about 0-95.0 weight percent and preferably, about 0-85.0 weight percent.

Coefficient of Friction

The feeding of paper into printing presses or electrophotographic copiers depends upon individual sheets being fed from a stack of the paper, and the mode of transfer of the sheet into the printing press or photocopier varies with the machine. The success in feeding single sheets depends upon separating each sheet from the sheet underneath cleanly without dragging the second sheet or multiple sheets into the printer. In the case of carbonless paper, there are several sheets and the sheets have coatings which differ in surface character.

The coefficient of friction between two surfaces is the ratio of the force required to move one over the other to the total force pressing the two together. If F is the force required to move one surface over the other, and W is the force pressing the surfaces together, the coefficient of friction $\mu = F/W$. Coefficient of friction is unitless and ranges from 0.0 to 1.0.

When a sliding force is applied to the top sheet on a stack of paper, the ratio of the sliding force to the force between the sheets which must be overcome to initiate movement is called the "static coefficient of friction." After the top sheet has begun to slide over the second sheet, the ratio of the sliding force to the force between the sheets that must be overcome to maintain sheet movement is called the "kinetic coefficient of friction." Static coefficient of friction is usually higher than kinetic coefficient of friction. While both coefficients of friction are important, the static coefficient of friction is more important when considering the feeding of paper into copiers and printing presses.

Printing presses and electrophotographic copiers are designed to feed paper into the machine by several mechanisms. The paper may be fed by a vacuum pickup and transfer system, by a roller or belt which exerts pressure on the top sheet in the stack, by a roller or belt which exerts pressure on the top sheet in the stack in combination with a retard roller or belt beneath the stack, or by other suitable means.

In one common mechanism, a roller or belt pressed against the top sheet of the paper stack is employed as the feed means. These feed means move into engagement with the top sheet of the stack, exert pressure on the top sheet, usually by buckling the sheet, and releases and separates the sheet from the stack. The sheet can then be fed through "take away rolls" into the copier. The feed means usually remain at a fixed position in relation to the stack during sheet feeding.

In another feed system, a forward moving belt removes the top sheet from a stack of paper and advances the sheet to a set of pinch rolls which then feed the sheet into the imaging and toner transfer stations. To prevent double feeds, a retard roller under the feed belt catches any second sheet that begins to transfer with the top sheet.

When carbonless papers are employed in feed mechanisms containing rollers, belts, or retard mechanisms, a smudge mark often develops on the CF surface of a sheet. Smudging is caused by coefficient of friction mismatch between contacting surfaces of consecutive sheets of paper and results from CB capsule rupture and color-former transfer to the CF surface. Capsule rupture can be caused by the feed mechanism (such as a belt or roller) sliding across the paper rather then smoothly feeding the paper into the photocopier or printing press. Capsule rupture can also be caused by double or multiple sheet feeds of carbonless papers into the feeder assembly and subsequent abrasion by the retard roller along the CB surface. Transfer of color-former from the CB sheet to the CF surface can take place in the paper feed mechanism as another sheet is fed, within the copier, or in the collection tray as the sheets lie on top of each other.

As noted above, carbonless copy paper is often collated into form-sets. The sequence of sheets in a "straight sequence set" is as follows:

For 2-part sets --	
First sheet:	CB = coated back
Second sheet:	CF = coated front
For 3-part sets--	
First sheet:	CB = coated back
Second sheet:	CFB = coated front and back
Third sheet:	CF = coated front
For 4-part sets--	
First sheet:	CB = coated back
Second sheet:	CFB = coated front and back
Third sheet:	CFB = coated front and back
Fourth sheet:	CF = coated front

For 2-part straight sequence form-sets, the interfaces are CB against CF and CF_{pc} against CB_{pc} (of the next form-set). For the CF/CB interface, the static coefficient of friction ranges from about 0.55 to 0.65. For the CF_{pc}/CB_{pc} interface, the static coefficient of friction is about 0.35. For 3-part straight sequence form-sets the interfaces are CB against CF (of the CFB sheet), CB (of the CFB sheet) against CF, and CF_{pc} against CB_{pc}

(of the next form-set). For both CB/CF interfaces, the static coefficient of friction is again about 0.55-0.65. For the CF$_{pc}$/CB$_{pc}$ interface the coefficient is again about 0.35. For 4-part and larger form-sets, only additional CB/CF interfaces are present.

The sequence of sheets in a "reverse sequence form-set" is as follows:

For 2-part sets--	
First sheet:	CF = coated front
Second sheet:	CB = coated back
For 3-part sets--	
First sheet:	CF = coated front
Second sheet:	CFB = coated front and back
Third sheet:	CB = coated back
For 4-part sets--	
First sheet:	CF = coated front
Second sheet:	CFB = coated front and back
Third sheet:	CFB = coated front and back
Fourth sheet:	CB = coated back

For 2-part reverse sequence form-sets, the interfaces are CF$_{pc}$ against CB$_{pc}$ and CB against CF (of the next form-set). As noted above, for the CF$_{pc}$/CB$_{pc}$ interface, the static coefficient of friction is about 0.35. For the CF/CB interface the static coefficient of friction ranges from about 0.55 to 0.65. For 3-part reverse sequence form-sets, the interfaces are CF$_{pc}$ against CF (of the CFB sheet), CB (of the CFB sheet against CB$_{pc}$, and CB against CF (of the next form-set). For the CF$_{pc}$/CF interface the static coefficient of friction is about 0.50. For the CB/CB$_{pc}$ interface the coefficient of friction is also about 0.50. For the CB/CF interface the static coefficient of friction ranges from about 0.55 to 0.65. For 4-part or larger form-sets, only additional CB/CF interfaces are present.

Coefficient of Friction Tests

Coefficient of Friction was measured using an Instron Coefficient of Friction Fixture (Catalog No. 2810-005) installed on an Instron Testing Instrument. The fixture comprises a friction table, a sled, and a pulley. One piece of material is attached to the friction table. A second piece of material is attached to the 200 g 2⅜” x 2⅝ (6.0 cm x 6.7 cm) sled. The materials are positioned so that the interfaces between which the coefficient of friction is to be measured are in contact. The sled is connected through a low-friction pulley to the Instron load cell which detects the drag or friction. The force needed to draw the sled across the friction table is a measure of the friction between the two contacting surfaces. This force can be plotted, as for example, on a strip chart recorder.

Form-Set Constructions

Form-sets are prepared by stacking the collated carbonless paper, trimming, edge- padding, and fanning-out. The stack is first trimmed to align the edge to a uniform state. To ensure the edge of the stack remains uniform during the edge-padding step, the edge is preferably compressed by a weight. The amount of compression is not material as long as it is not so great as to rupture the capsules contained on the CB sheet [(preferably not more than about 50 psi (340 kPa)]. After 24 hours, the edge is adhesively edge-padded.

Edge-padding is accomplished by applying adhesive, as with a brush, along the edge of the stack. Sufficient amounts of padding adhesive are applied until excess adhesive runs down the edge of the stack. This assures complete adhesion between individual sheets of each form-set in the stack. Greater amounts cause no problem except to be wasteful. Compression is maintained for 24 hours while the edge padded sets are allowed to dry. All padding described herein used "3M Brand Padding Adhesive," available from the Carbonless

Products Department of 3M Company, St. Paul, MN.

It is more difficult to form a strong CB/CF bond in 2-part form sets than it is to form CB/CFB and CFB/CF bonds between the individual sheets of 3-part sets. In 4-part or greater sets, it is more difficult to form strong CFB/CFB bonds than it is to form strong CB/CFB and CFB/CF bonds. Consequently, in 4-part or greater sets, CFB/CFB bonds are the bonds most likely to break upon fan-out or crash printing. The most stringent testing of the ability to form strong bonds between sheets is in 2-part sets (CB/CF) and in 4-part sets (CFB/CFB), rather than in 3-part sets.

The quality of edge padding can be determined by two tests, one showing how readily a stack of collated sheets separates into sets ("Fan-Out Rating Test") and the other showing the strength of the adhesive bond between individual sheets of a set ("Bond Strength Test").

Fan-Out Rating Test

A stack of sets of collated sheets that has been edge-padded is tested for fan-out into sets as follows:

1) While gripping the edge-padded end of the stack with one hand and the unpadded end with the other, bend the stack into a "U" shape. Then while holding the stack horizontally, release the padded end, allowing that end to droop downward. If complete fan-out has been accomplished, rate as a 3.5; if not, continue.

2) Place the stack on a flat surface with fingers one inch (2.5 cm) back from the edge padded end on top and thumbs under the corners, and simultaneously fan upwards on both corners of the edge padded end. If complete fan-out has been accomplished, rate as 3.0; if not, continue.

3) Place on a flat surface with fingers on top and the thumbs under the edge-padded end approximately 3 inches (7.6 cm) from the corners of the edge-padded end, and simultaneously fan upwards once. If complete fan-out has been accomplished, rate as 2.5; if not, continue.

4) Place stack on a flat surface with fingers on top and thumbs under the edge-padded end wherever needed, and simultaneously fan upwards twice. If complete fan-out has been accomplished, rate as 2.0; if not, continue.

5) While holding the stack as in step 4), fan with both thumbs three times wherever needed. If complete fan-out has been accomplished, rate as 1.5; if not, continue.

6) While holding the stack as in step 4), fan with the thumbs six more times wherever needed. If complete fan-out is accomplished, rate as 1.0; if not continue.

7) While holding the stack as in step 4) continue to fan with the thumbs wherever needed. If complete or partial fan-out can be accomplished, rate as 0.5; if not, rate as 0.

Generally, the carbonless copy paper industry will accept a Fan-Out Rating of 2.0, but a higher value would be preferred.

Bond Strength Test

The strength of the adhesive bond between two individual sheets of a set of carbonless copy paper is tested using a tension measurement device, i.e., "Digital Force Gauge Model DFG RS-50" available from John Chatillon & Sons, Inc., Greensboro, NC. With the unpadded end of one sheet in the clamp, the unpadded end of the other sheet is gripped by the thumb, fingers, and palm of one hand and pulled slowly until the bond fails. In 4-part sets, measurements are made between the coated front sheet and a coated front and back sheet (CF/CFB), between two coated front and back sheets (CFB/CFB), and between a coated front and back sheet and the coated back sheet (CFB/CB). Typically, the lowest Chatillon "Bond Strength" in a 4-part set is CFB/CFB.

When the "Bond Strength" exceeds 10 N (10 Newtons) across a width of 8.5 inches (21.6 cm), a set of the edge-bonded sheets should withstand premature separation in any ordinary printing operation, including crash printing or perforating.

Toner Adhesion

The quality of toner adhesion can be determined by three tests, one showing the ease of scraping fused toner off the sheet ("Knife-Rubbing Test"), one showing the ease of toner removal with a repositionable removable tape ("Low-Tack Tape Peel Test"), and one showing the ease of toner removal with a permanent nonremovable tape ("High-Tack Tape Peel Test").

Knife Rubbing Test

Carbonless paper is imaged in a commercial electrophotographic copier such as a Xerox Model 1090. A knife edge is scraped lightly across the fused toner powder image on the paper and the ease of toner removal is subjectively evaluated.

Tape Peel Tests

Tape peel tests determine toner adhesion to the pad coat of the paper by measuring the approximate toner percentage removed when tape is applied to and pulled off the toned sheet.

A piece of tape approximately 2-3 inches (5.1-7.6 cm) long was placed on the sheet of carbonless paper that had been imaged in a Xerox Model 1090 photocopier. The image had both large solid areas and fine line areas. The tape was pressed onto the imaged paper by rolling it 4 times with a 4.5 lb (2.0 kg) roller. The tape was then removed and the approximate amount of toner removed determined.

A "low-tack tape test" was run using 3M Scotch Brand #811 Magic Tape. This is a removable tape and uses a Post-It^{TM} repositionable type adhesive. A "high-tack tape test" was run using 3M Scotch Brand #810 Magic Tape. This is a non-removable tape and uses a permanent adhesive. It should be noted that both tapes can be removed from the paper because of the fan-out coating on the paper. It should also be noted that when the high-tack tape peel test was run on paper having no pad coat, the paper was torn by removal of the tape.

The present invention will be further described by reference to the following detailed examples. These examples are presented to illustrate the advantages and operation of the invention and are not to be construed as limiting its scope.

EXAMPLES

Examples 1 and 2 show the preparation and evaluation of CF and CB pad coats (CF_{pc} and CB_{pc}).

Example 1

Preparation and Evaluation of Colloid Containing CF Pad Coat:

CF pad coat solutions were prepared by mixing the materials shown below. To the indicated amount of water were added solutions of FC-829, and 32% starch solution. The pH, now about 3, was adjusted to 10 by addition of 50% aqueous NaOH solution, and colloidal silica was added (pH is adjusted prior to addition of the colloid). A control pad-coat was prepared by using no colloid and is labeled 0%. In all cases, the total pad-coat solutions contained 12,000 g of material.

The 32% solution of starch binder for the CF pad coat was prepared by adding 3,200 g of GPC Oxidized Corn Starch (available from Grain Products Corporation, Muscatine IA) to 6,800 g of water in a Groden Model TDB/7 Steam Jacket Kettle. The mixture was heated at 200 °F (93°C) for 1 hr.

FC-829 is a fluorochemical abhesive material available as a 30% aqueous solution from 3M Company, St. Paul, MN.

Nalco 1140 is a colloidal silica solution containing 40% silica and is available from Nalco Corp., Naperville, IL.

	Amount of Silica				
weight of material gm	**0%**	**0.1%**	**0.5%**	**2.5%**	**5.0%**
water	10,738	10,708	10,588	9,988	9,238
FC-829 sol'n	194	194	194	194	194
starch sol'n	1,068	1,068	1,068	1,068	1,068
silica sol'n	0	30	150	750	1,500

The weight percent silica of the total solids is the same as the weight percent silica in the dried coating.

silica	0%	2.9%	13.0%	42.8%	60.0%

The solutions were coated on a reverse roll coater onto 20 pound Xerographic bond setting the nip roll pressure to give the coating weights shown below. Ream weight is defined as the weight of 500 sheets of 17" x 22" (43.2 cm x 55.9 cm) paper.

0.0% silica	0.301 pounds per ream
0.1% silica	0.295 pounds per ream
0.5% silica	0.572 pounds per ream
2.5% silica	0.472 pounds per ream
5.0% silica	0.721 pounds per ream

The coated paper was dried in a forced air oven at 250 °F (121 °C) at a coating speed of 200 ft./minute. The coated CF sheets were made into 2-part sets using a CB sheet available from the Carbonless Products Department of 3M Company, St Paul, MN under the name of "3M Blue Purple CB." This sheet is coated with a pad coat that does not contain colloidal material. The coefficient of friction of the CF_{pc} surface was measured against CB_{pc} surface. The adhesion and fan-apart were measured as described above. Results of the evaluation, shown in Table 1, demonstrate an increase in both coefficient of friction and surface energy of the contacting surfaces. Fan apart and adhesion between the CF and CB sheets of padded form-sets is maintained.

Table 1 Evaluation of CF Pad Coat with Silica

	Coefficient of Friction[1]				
Silica	Static	Kinetic	Surface Energy[2]	Fan Apart	Bond Strength[3]
0.0%	0.38	0.35	54.4	3.0	21.3
0.1%	0.40	0.38	54.8	3.0	21.9
0.5%	0.46	0.42	57.8	3.0	22.9
2.5%	0.58	0.53	60.7	2.5	25.9
5.0%	0.58	0.53	60.6	2.5	26.1

[1] Coefficient of friction between the CF pad coat containing silica against commercial CB pad coat without silica.

[2] Surface energy in dyne/cm.

[3] Bond Strength in Newton/21.6 cm.

Example 2

Preparation and Evaluation of Colloid Containing CB Pad Coat:

CB pad coat solutions were prepared by mixing the materials shown below. To the indicated amount of water were added solutions of FC-829 fluorochemical abhesive, Tinapol PT-150, and Nalco 7569 defoamer. The pH, now between 4 and 5, was adjusted to 10 by addition of 50% aqueous NaOH solution, and colloidal silica was added. A control pad-coat was prepared by using no colloid and is labeled 0%. The weights shown below are gross weights of solution and include water present. In all cases, the total pad-coat solutions contained 6,000 g of material. FC-829 is a fluorochemical abhesive material available as a 30% aqueous solution from 3M Company, St. Paul, MN. Tinapol PT-150 is an optical brightener available from Ciba-Geigy, Inc., Ardsley, NY. It is an aqueous solution containing 28% solids. Nalco 7569 is a defoamer available from Nalco Company, Naperville, IL. It is 100% active liquid. Nalco 1140 is a colloidal silica solution containing 40% silica and is also available from Nalco Corp., Naperville IL.

Amount of Silica					
weight of material (gm)	**0.0%**	**0.1%**	**0.5%**	**2.5%**	**5.0%**
water	5,927	5,912	5,852	5,552	5,177
FC-829 sol'n	34	34	34	34	34
Tinapol sol'n	37	37	37	37	37
Nalco 7569 sol'n	2	2	2	2	2
Silica sol'n	0	15	75	375	750

The weight percent silica of the total solids is the same as the weight percent silica in the dried coating.

Silica	0.0%	21.0%	57.1%	86.9%	93.0%

The solutions were blade coated at 200 ft/min onto the front surface of a CB carbonless paper sheet available from the Carbonless Products Department of 3M Company, St Paul, MN under the name of "3M Blue Purple CB." This was followed by drying in a forced air oven at 250 °F (121 °C). The dry weight of these coating formulations varied from that for the CF pad coat in Example 1, and the relative amount of silica in the dry coating weight was much greater in this Example. Ream weight is defined as the weight of 500 sheets of 17" x 22" (43.2 x 55.9 cm) paper. The coating weights were:

0.0% silica	.012 pounds per ream
0.1% silica	.016 pounds per ream
0.5% silica	.025 pounds per ream
2.5% silica	.068 pounds per ream
5.0% silica	.143 pounds per ream

The coated CB sheet was made into 2-part set using a CF sheet available from the Carbonless Products Department of 3M Company, St Paul, MN under the name of "3M Blue Purple CF". This sheet is coated with a pad coat that does not contain colloidal material. The coefficient of friction of the CB_{pc} surface was measured against CF_{pc} surface which did not contain colloidal particles. The adhesion and fan apart were measured as described above. Results of the evaluation, shown in Table 2, demonstrate an increase in both coefficient of friction and surface energy of the contacting surfaces. Fan apart and bond strength measurements demonstrate that addition of colloidal particles to the pad coat has little effect on these form-set properties.

Table 2 - Evaluation of CB Pad Coat with Silica

% Silica	Coefficient of Friction[1] Static	Coefficient of Friction[1] Kinetic	Surface Energy[2]	Fan Apart	Bond Strength[3]
0.0%	0.37	0.35	53.6	3.5	27.3
0.1%	0.38	0.35	54.9	3.0	27.7
0.5%	0.44	0.42	57.4	3.0	27.2
2.5%	0.49	0.46	62.8	3.0	27.7
5.0%	0.50	0.47	61.4	3.0	30.3

[1] Coefficient of friction between the CB pad coat containing silica against a commercial CF pad coat without silica.

[2] Surface energy in dyne/cm.

[3] Bond Strength in Newton/21.6 cm

Example 3

Preparation and Evaluation of Colloid Containing CB and CF Pad Coats:

The CF and CB sheets prepared as in Examples 1 and 2 were used to prepare precollated 2-part form sets. These sets have only CB/CF and CB_{pc}/CF_{pc} interfaces. The sheets were imaged in a Xerox Model 1090 electrophotographic copier which uses pressure belts for feeding paper into the copier. The sheets were mated such that the level of colloid loading was the same. That is, each CF_{pc} and CB_{pc} had the same colloid and same percent colloid. The coefficient of friction between the CF_{pc} and CB_{pc} faces were measured. The stack was padded and tested for fan-apart and bond strength. Results are shown in Table 3.

Table 3 - Evaluation of Colloid Containing CB and CF Pad Coats

% Silica	Coefficient of Friction[1] Static	Coefficient of Friction[1] Kinetic	Fan Apart	Bond Strength[2]
0.0%	0.36	0.34	3.5	20.6
0.1%	0.42	0.40	3.5	22.2
0.5%	0.55	0.52	3.0	19.4
2.5%	0.70	0.58	2.5	22.4
5.0%	0.71	0.61	2.5	22.4

[1] Coefficient of friction between CF_{pc} and CB_{pc} containing silica at the indicated levels

[2] Bond Strength in Newton/21.6 cm

After imaging in an electrophotographic copier (Xerox Model 1090) which uses a pressure belt to feed the paper into the copier, tests to determine adhesion of the toner to the pad coats were performed. The original used to create the copy on the test surfaces contained broad image areas as well as areas of fine lines. Toner adhesion was evaluated by observing the amount of toner removed by rubbing with the edge of knife and by observing the amount of image remaining after a pressure sensitive tape was removed from the imaged area. Two tapes were used, the first 3M Scotch Brand #811 Magic Tape is coated with a low tack, repositionable adhesive. The second 3M Scotch Brand Type 811 Magic Tape is coated with a high tack permanent adhesive. The results show that between 0.5 and 2.5% silica loading, a much greater anchorage of the toner was detected using the knife rub test. An even greater difference was noted with the tape test where the low adhesion tape removed none of the image from the sheets with 2.5% silica and the very aggressive adhesive tape removed only 40 to 20% of the image. A difference in toner adhesion between the pad coats was expected because of the difference in the formulations for the CB and CF pad coats. Results were as follows:

	Knife Rub Test		Low-Tack Tape Test		High-Tack Tape Test	
% Silica	CF_{pc}	CB_{pc}	CF_{pc}	CB_{pc}	CF_{pc}	CB_{pc}
0.0%	fair	fair	25	5	95	90
0.1%	fair	fair	15	--	95	--
0.5%	good	fair	25	--	95	--
2.5%	very good	good	0	0	40	20
5.0%	very good	very good	0	0	10	5

Smudging results from CB capsule rupture during paper feed and subsequent color-former transfer to a CF developer sheet. Capsule rupture is caused by the feed mechanism (such as a belt or roller) sliding across the paper rather than smoothly feeding the paper into the photocopier or printing press. Smudging results from coefficient of friction mismatch between consecutive sheets of paper and is caused by dragging the CF sheet over the CB sheet. This commonly takes place under the force of the retard roller and nip rollers of the feed mechanism.

The extent of smudge introduced by a pressure belt used to feed carbonless paper was subjectively evaluated by observing the percentage of sheets having a smudge penetrating 1.5 inches from the edge of the sheet. The results, shown below, indicate a dramatic reduction in the amount of smudge introduced by the friction feed retard action in the copier upon addition of small amounts of colloid to the pad coat. Smudge reduction results from improved paper feed.

Amount of Silica	% of Sheets Smudged
0.0%	83%
0.1%	33%
0.5%	0%
2.5%	0%
5.0%	0%

Example 4

Effect of Colloid Size

CF_{pc} and CB_{pc} pad coat solutions were prepared as in Examples 1 and 2 with three different colloidal silicas differing in particle size and surface areas. Static and Kinetic coefficient of friction measurements and fan apart, bond strength, knife rub, and toner adhesion tests were performed as described above. The results, shown below, indicate colloid size can be varied over a broad range to provide increased coefficient of friction without adversely affecting fan apart or bond strength.

	Coefficient of Friction[1]			
% Silica	Static	Kinetic	Fan Apart	Bond Strength
Nalco 2326				
Average Particle size = 5 nm; Average Surface Area = 600 m^2/gm				
0.0%	0.35	0.33	3.5	22.3
0.1%	0.42	0.40	3.5	24.4
0.5%	0.58	0.57	3.0	25.5
2.5%	0.66	0.56	2.0	26.4
5.0%	not tested---------------------------			
Nalco 1140				
Average Particle size = 15 nm; Average Surface Area = 200 m^2/gm				
0.0	0.36	0.33	3.5	20.6
0.1%	0.42	0.40	3.5	22.2
0.5%	0.55	0.52	3.0	19.4
2.5%	0.70	0.58	2.5	22.4
5.0%	0.71	0.61	2.5	22.4
Nalco 2329				
Average Particle size = 75 nm; Average Surface Area = 40 m^2/gm				
0.0%	0.37	0.33	3.5	22.9
0.1%	0.41	0.38	3.5	24.8
0.5%	0.53	0.52	3.5	25.2
2.5%	0.64	0.58	2.5	26.8
5.0%	0.71	0.68	2.0	24.2

Toner anchorage and smudge were also evaluated for the pad coats with the different sized colloids. The results, shown below, indicate colloid size can be varied over a broad range to provide improved toner adhesion.

	Knife Rub Test		Low-Tack Tape Test		High-Tack Tape Test	
% Silica	CF_{pc}	CB_{pc}	CF_{pc}	CB_{pc}	CF_{pc}	CB_{pc}
Nalco 2326						
0.0%	poor	fair	25	10	95	95
0.1%	poor	---	20	--	95	95
0.5%	fair	fair	15	--	95	--
2.5%	fair	--	0	0	95	85
5.0%	very good	--	0	0	15	--
Nalco 1140						
0.0%	fair	fair	25	5	95	90
0.1%	fair	fair	15	--	95	--
0.5%	good	fair	25	--	95	--
2.5%	very good	good	0	0	40	20
5.0%	very good	very good	0	0	10	5
Nalco 2329						
0.0%	poor	poor	15	15	95	95
0.1%	poor	poor-fair	15	5	95	95
0.5%	poor	fair	5	2	95	95
2.5%	fair	fair	0	0	95	90
5.0%	good	good	0	0	90	65

Smudge was determined as described above in Example 3. Results, shown below, indicate a broad range of colloidal particle size is effective in reducing smudge and improving paper feed. There is a difference in the efficiency of different size colloids in the elimination of smudge and in toner adhesion.

% Silica	% of Sheets Smudged
Nalco 2326	
0.0%	80%
0.1%	100%
0.5%	25%
2.5%	0%
Nalco 1140	
0.0%	83%
0.1%	33%
0.5%	0%
2.5%	0%
5.0%	0%
Nalco 2329	
0.0	100%
0.1%	66%
0.5%	20%
2.5%	20%
5.0%	0%

Examples 5-10

Preparation and Evaluation of Various Colloids as CF Pad Coats

The following Examples demonstrate that colloids in addition to silica are useful in the present invention. Pad coat formulations were prepared as described below. In these examples, the starch solution was 20% solids and the total weight of all coating formulations was 35 g. The formulations were mixed, stirred, and coated onto a 15 lb basis weight paper using a #8 Meyer rod. The coatings were dried by passing through a Pako heat roller at 250 °F (121 °C) for 2 min. Samples were left at 72 °F/50% relative humidity overnight. The coated CF_{pc} side of the samples were tested against an identical CF_{pc} sheet for static and kinetic coefficient of friction.

It should be noted that drawdown samples usually have a higher coefficient of friction than machine coated samples. This is due to the nature of coating technique.

Example 5

weight of material gm	Colloid Level 0%	0.3%	0.75%	1.5%	3.0	7.5%
Water	26.31	25.75	24.92	23.54	20.78	12.49
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
Alumina sol[1]	0.00	0.55	1.38	2.76	5.53	13.82

[1] Alumina was a 19% solids sol of alumina sold by Vista Chemical, Ponca City, OK. It has a pH of 4 and a particle size of 75 nm.

Example 6

weight of material gm	Colloid Level 0%	0.3%	0.75%	1.5%	3.0	7.5%
Water	26.31	25.78	24.99	23.68	21.06	13.18
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
Zirconia sol'n[2]	0.00	0.53	1.31	2.63	5.25	13.13

[2] Zirconia was a 20% sol of Nyacol Zr 50-20 sold by Nyacol Products, Ashland MA. It has a pH of 3.0 and particle size of 50 nm.

Example 7

weight of material gm	Colloid Level 0%	 0.3%	 0.75%	 1.5%	 3.0	 7.5%
Water	26.31	25.35	23.92	21.53	16.76	2.44
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
Titania[3]	0.00	0.96	2.39	4.77	9.55	23.86

[3] TiO_2 (titania) is 11.3% solids sold by Nalco Chemical, Naperville, IL under the name of Nalco 885N-126. The material has a pH 10.1 and particle size of 20 nm.

Example 8

weight of material gm	Colloid Level 0%	 0.3%	 0.75%	 1.5%	 3.0	 7.5%
Water	26.31	25.75	24.92	23.54	20.78	12.49
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
Sb_2O_5[4]	0.00	0.21	0.53	1.05	2.10	5.25

[4] Sb_2O_5 (antimony pentoxide) is 50% solids sold by Nyacol Products, Ashland MA under the name of Nyacol A-1550. It has a pH of 4-6 and a particle size of 30 nm.

Example 9

weight of			Colloid Level			
material gm	0%	0.3%	0.75%	1.5%	3.0	7.5%
Water	26.31	25.75	24.92	23.54	20.78	12.49
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
$CaCO_3$[5]	0.00	0.11	0.26	0.53	1.05	2.63

[5] $CaCO_3$ (calcium carbonate) is a precipitated $CaCO_3$ available from Pfizer under the name of Multiflex MM. It has a particle size of 70 nm. It was added as a solid and dispersed in water with vigorous stirring.

Example 10

weight of			Colloid Level			
material gm	0%	0.3%	0.75%	1.5%	3.0	7.5%
Water	26.31	26.00	25.53	24.76	23.33	18.59
FC-829 sol'n	0.48	0.48	0.48	0.48	0.48	0.48
Starch sol'n	8.22	8.22	8.22	8.22	8.22	8.22
Nalco 1034A	0.00	0.31	0.77	1.54	3.09	7.72

Nalco 1034A is 34% solids sold by Nalco Chemical, Naperville, IL. It has a pH of 2.8 and a particle size of 20 nm.

Table 4 - Evaluation of Different Colloids on the Coefficient of Friction of CF Pad Coats

Example 5 - Coefficient of Friction

Alumina	Static	Kinetic
0.0%	0.43	0.41
0.3%	0.44	0.40
0.75	0.46	0.42
1.5%	0.47	0.43
3.0%	0.50	0.51
7.5%	0.67	0.66

Example 6 - Coefficient of Friction

Zirconia	Static	Kinetic
0.0%	0.43	0.41
0.3%	0.44	0.41
0.75	0.48	0.48
1.5%	0.52	0.51
3.0%	0.66	0.64
7.5%	0.70	0.66

Example 7 - Coefficient of Friction

Titania	Static	Kinetic
0.0%	0.43	0.41
0.3%	0.44	0.41
0.75	0.44	0.42
1.5%	0.47	0.44
3.0%	0.54	0.50
7.5%	0.57	0.54

Example 8 - Coefficient of Friction

Sb_2O_5	Static	Kinetic
0.0%	0.45	0.45
0.3%	0.61	0.57
0.75	0.62	0.58
1.5%	0.64	0.60
3.0%	0.69	0.64
7.5	0.79	0.78

Example 9 - Coefficient of Friction

$CaCO_3$	Static	Kinetic
0.0%	0.39	0.36
0.3%	0.41	0.41
0.75	0.42	0.44
1.5%	0.46	0.49
3.0%	0.56	0.57

Example 10 - Coefficient of Friction

Nalco 1034A	Static	Kinetic
0.0%	0.43	0.41
0.3%	0.56	0.56
0.75	0.64	0.59
1.5%	0.68	0.61
3.0%	0.69	0.63
7.5%	0.71	0.65

Examples 11-14

Examples 11-14 demonstrate that binders in addition to starch are useful for preparing CF pad coats of the present invention (CF_{pc}). Pad coat formulations were prepared as described below. In these examples, the binder solution was as indicated, and the total weight of all coating formulations was 50 g. The formulations were mixed, stirred and coated onto a 15 lb basis weight paper using a #8 wire wound rod (Meyer rod). The coatings were dried by passing through a Pako heat roller at 250 °F (121 °C) for 2 min. Samples were left at 72 °F/50% relative humidity overnight and tested for static and kinetic coefficient of friction.

In Examples 11-14, the binder comprised 5% by weight of the coating solution. In all cases, the colloid used was Nalco 1030, a colloidal silica available from Nalco Chemical Co., Naperville, IL. It contains 30% SiO_2 solids and has a particle size of 13 nm and a pH of 10.2. The amount of colloid added is indicated as a percent by weight of the coating solution.

The binders used were as follows:

GPA Oxidized Corn Starch was used as a 20% starch solution. It was prepared as indicated in Examples 5-9 above. Dow 620 is a 50% solids styrene/butadiene latex from Dow Chemical Company, Midland MI. Vinol 205 is a Polyvinyl Alcohol (PVA) available from Air Products Co., Allentown PA. It was made into a 16% solids solution by heating with stirring at 185°F (85°C). Ecosol 45 is a phosphated wheat starch from Ogilvie Mills, Inc., Minnetonka, MN. It was made into a 10% solids solution by dissolving in water.

Example 11

weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	37.58	37.08	36.33	35.08
FC-829 sol'n	0.68	0.68	0.68	0.68
Starch sol'n	11.74	11.74	11.74	11.74
Nalco 1030 sol'n	0.00	0.50	1.25	2.50

Example 12

weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	44.32	43.82	43.07	41.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Dow 620 latex	5.00	5.00	5.00	5.00
Nalco 1030 sol'n	0.00	0.50	1.25	2.50

Example 13

weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	33.70	33.20	32.45	31.20
FC-829 sol'n	0.68	0.68	0.68	0.68
Vinol 205	15.63	15.63	15.63	15.63
Nalco 1030 sol'n	0.00	0.50	1.25	2.50

Example 14				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	24.32	23.82	23.07	21.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Ecosol 45	25.00	25.00	25.00	25.00
Nalco 1030 sol'n	0.00	0.50	1.25	2.50

The coated CF_{pc} side of the samples were evaluated against identical CF_{pc} sheets for static and kinetic coefficient of friction. Results, shown in Table 5, demonstrate an increase in coefficient of friction by addition of colloid regardless of the binder used. Due to the nature of coating technique drawdown samples have a higher coefficient of friction than similar machine coated samples. Nevertheless, the relationship of added colloid to increased coefficient of friction is again seen in these situations.

Table 5 - Coefficient of Friction of CF Pad Coats (CF_{pc}) Employing Different Binders

Example 11 - Coefficient of Friction

5% Corn Starch	Static	Kinetic
0.0%	0.42	0.38
0.3%	0.54	0.53
0.75%	0.69	0.59
1.5%	0.72	0.62

Example 12 Coefficient of Friction

5% Dow 620	Static	Kinetic
0.0%	0.52	0.53
0.3%	0.57	0.58
0.75%	0.63	0.61
1.5%	0.67	0.62

Example 13 - Coefficient of Friction

5% Vinol 205	Static	Kinetic
0.0%	0.48	0.47
0.3%	0.51	0.49
0.75%	0.57	0.54
1.5%	0.64	0.58

Example 14 - Coefficient of Friction

5% Ecosol 45	Static	Kinetic
0.0%	0.36	0.32
0.3%	0.50	0.51
0.75%	0.62	0.57
1.5%	0.65	0.59

Example 15-17

Examples 15-17 were run as in Examples 11-14 above, except that the binder comprised 2% by weight of the coating solution. The colloid used was again Nalco 1030 and the binders used were again GPA Oxidized Corn Starch, Vinol 205 Polyvinyl Alcohol (PVA), and Ecosol 45 phosphated wheat starch.

Example 15				
weight of material gm	Colloid Level			
	0%	0.3%	0.75	1.5%
Water	44.32	43.82	43.07	41.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Starch sol'n	5.00	5.00	5.00	5.00
Nalco 1030[1]	0.00	0.50	1.25	2.50

Example 16				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	43.07	42.57	41.82	40.57
FC-829 sol'n	0.68	0.68	0.68	0.68
Vinol 205	6.25	6.25	6.25	6.25
Nalco 1030[1]	0.00	0.50	1.25	2.50

Example 17				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	39.32	38.82	38.07	36.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Ecosol 45	10.00	10.00	10.00	10.00
Nalco 1030	0.00	0.50	1.25	2.50

The coated CF_{pc} side of the samples were again evaluated against identical CF_{pc} sheets for static and kinetic coefficient of friction. Results, shown in Table 6, demonstrate an increase in coefficient of friction by addition of colloid regardless of the weight percent binder level used. The relationship of added colloid to increased coefficient of friction is again seen in these situations.

Table 6 - Coefficient of Friction of CF Pad Coats (CF_{pc}) Employing DifferentBinders

Example 15 - Coefficient of Friction		
2% Corn Starch	**Static**	**Kinetic**
0.0%	0.46	0.48
0.3%	0.59	0.56
0.75%	0.68	0.61
1.5%	0.72	0.64
Example 16 - Coefficient of Friction		
2% Vinol 205	**Static**	**Kinetic**
0.0%	0.55	0.55
0.3%	0.56	0.56
0.75%	0.61	0.58
1.5%	0.64	0.58
Example 17 - Coefficient of Friction		
2% Ecosol 45	**Static**	**Kinetic**
0.0%	0.42	0.49
0.3%	0.57	0.53
0.75%	0.64	0.57
1.5%	0.68	0.59

Examples 18 and 19

Examples 18 and 19 were run as in Examples 11-14 above, except that the binder comprised 10% by weight of the coating solution. The colloid used was again Nalco 1030 and the binders used were GPA Oxidized Corn Starch, and Vinol 205 Polyvinyl Alcohol (PVA).

Example 18				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	24.32	23.82	23.07	21.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Starch sol'n	25.00	25.00	25.00	25.00
Nalco 1030	0.00	0.50	1.25	2.50

Example 19				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	18.07	17.57	16.82	15.57
FC-829 sol'n	0.68	0.68	0.68	0.68
Vinol 205	31.25	31.25	31.25	31.25
Nalco 1030	0.00	0.50	1.25	2.50

The coated CF_{pc} side of the samples were again evaluated against identical CF_{pc} sheets for static and kinetic coefficient of friction. Results, shown in Table 7, demonstrate an increase in coefficient of friction by addition of colloid regardless of the weight percent binder level used. The relationship of added colloid to increased coefficient of friction is again seen in these situations.

Table 7 - Coefficient of Friction of CF Pad Coats (CF_{pc}) Employing Different Binders

Example 18 - Coefficient of Friction

10% Corn Starch	Static	Kinetic
0.0%	0.38	0.33
0.3%	0.46	0.46
0.75%	0.72	0.72
1.5%	0.77	0.72

Example 19 - Coefficient of Friction

10% Vinol 205	Static	Kinetic
0.0%	0.45	0.44
0.3%	0.46	0.44
0.75%	0.46	0.44
1.5%	0.52	0.48

Example 20

Example 20 was run as in Examples 11-14 above, except that the binder was Ecosol 45 phosphated wheat starch and comprised 8% by weight of the coating solution. The colloid used was Nalco 1030.

weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	9.32	8.82	8.07	6.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Ecosol 45	40.00	40.00	40.00	40.00
Nalco 1030	0.00	0.50	1.25	2.50

The coated CF_{pc} side of the samples were again evaluated against identical CF_{pc} sheets for static and kinetic coefficient of friction. Results are shown below.

Table 8 - Coefficient of Friction of CF Pad Coats (CF_{pc}) Employing DifferentBinders

Example 20 - Coefficient of Friction		
8% Ecosol 45	**Static**	**Kinetic**
0.0%	0.34	0.30
0.3%	0.42	0.48
0.75%	0.60	0.56
1.5%	0.65	0.60

Examples 21 and 22

Example 21 and 22 were run as in Examples 11-14 above, except that in Example 21 the binder was Dow 620 Latex and comprised 1% by weight of the coating solution and in Example 22 the binder was Dow 620 styrene/butadiene latex and comprised 2.5% by weight of the coating solution. The colloid used was Nalco 1030.

Example 21				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	48.32	47.82	47.07	45.82
FC-829 sol'n	0.68	0.68	0.68	0.68
Dow 620 latex	1.00	1.00	1.00	1.00
Nalco 1030	0.00	0.50	1.25	2.50

Example 22				
weight of material gm	**Colloid Level**			
	0%	**0.3%**	**0.75**	**1.5%**
Water	46.82	46.32	45.57	44.32
FC-829 sol'n	0.68	0.68	0.68	0.68
Dow 620 latex	2.50	2.50	2.50	2.50
Nalco 1030	0.00	0.50	1.25	2.50

The coated CF$_{pc}$ side of the samples were again evaluated against identical CF$_{pc}$ sheets for static and kinetic coefficient of friction. Results are shown below.

Table 8 - Coeffiicient of Friction of CF Pad Coats (CF$_{pc}$) Employing Different Binders

Example 21 - Coefficient of Friction		
1% Dow 620	**Static**	**Kinetic**
0.0%	0.52	0.53
0.3%	0.60	0.57
0.75%	0.67	0.64
1.5%	0.71	0.66
Example 22 - Coefficient of Friction		
2.5% Dow 620	**Static**	**Kinetic**
0.0%	0.51	0.48
0.3%	0.60	0.58
0.75%	0.66	0.64
1.5%	0.67	0.63

Examples 23 - 26

Examples 23-26 demonstrate the use of silicone abhesives for pad-coatings (pad-coats) for carbonless papers. The silicone system used as an abhesive for evaluation in Examples 23-26 was silicone PC 104 in conjunction with catalyst designated PC 60 and crosslinker PC 31. All are availible from Rhone-Poulenc. PC 104 is beleived to be a polydimethyl siloxane. PC 31 is believed to be a silane hydride crosslinker. PC 60 is believed to be a platinum catalyst. These materials are provided as an emulsion in water at about 40% solids and are very convenient for preparing pad-coats.

Example 23

The effect of adding colloidal particles to a silicone abhesive was determined by measuring and comparing coefficient of friction and fan-apart of a pad-coat formulation made without colloidal particles with a pad-coat formulation made with colloid particles added.

A pad-coat solution was prepared by first preparing a solution of a polymer thickener in water. The polymer thickener gives the coating solution good coating properties. Water soluble polymers such as starch, hydroxyethyl cellulose (HEC), carboxymethyl cellulose (CMC), sodium alginate, and polyvinyl alcohol may be used.

A 0.75% polymer thickener solution was prepared by heating 198.5 grams of water to about 40°C and then adding 1.5 g of hydroxyethyl cellulose (Natrosol 250 HHR available from the Aqualon Company). The mixture became clear after stirring for 10 minutes; the many small suspended bubbles settled out overnight. Other concentrations of polymer thickener solutions were prepared in a similar manner.

Pad-coat solutions were prepared by adding various amounts of polymer thickener solution to the PC 104 in a beaker, then adding the water. PC 31 was added, followed by the PC 60. The mixture was stirred slowly to avoid incorporation of air for about 30 minutes. The solutions were coated on 15 pound basis weight paper with a #8 Meyer rod and dried in a forced air oven at 250°F (121°C) for two minutes. In all, 5 pad-coated papers were made. Fan-apart and coefficient of friction were measured for each coating.

The results, shown in Table 9, indicate the silicone functions well as an abhesive for carbonless paper independent of the thickener concentration. The low coefficients of friction indicate that the pad-coated surfaces CB_{pc} and CF_{pc} will will differ from the functional CF and CB surfaces by greater than 0.2 units.

Table 9 - Effect of Thickener on Fan-Apart and COF

wt. material	A	B	C	D	E
water	43.75	27.08	10.42	18.75	10.42
PC 104	5.74	5.74	5.74	5.74	5.74
PC 60	0.39	0.39	0.39	0.39	0.39
PC 31	0.12	0.12	0.12	0.12	0.12
HEC Solution (g)	0.00	16.67	33.33	25.00	33.33
Conc.		0.75%	0.75%	1.5%	1.5%
% Thickener	0.00%	0.25%	0.5%	0.75%	1.00%
TOTAL wt. (g)	50.00	50.00	50.00	50.00	50.00
Fan-apart	3.5	3.5	3.5	3.5	3.5
COF	0.28	0.27	0.26	0.24	0.24

Example 24

For the coating solutions with colloid, the thickener was added to the silicone (PC 104), followed by additional water, colloid, silicone catalyst (PC 31) and crosslinker (PC 60). The concentration of hydroxyethyl cellulose (HEC) thickener was 0.5% in water. Pad-coat solutions were prepared as in Example 23 above.

Table 10 demonstrates the effect of colloid addition on pad-coat properties. Addition of colloid is seen to increase toner adhesion while improving both coefficient of friction and fan-apart. In all samples, 2.0% silicone was present in the pad-coat formulation. As shown in samples **B** and **C**, at 2-3% colloidal silica good coefficient of friction is achieved while maintaining satisfactory fan-apart. In these experiments, fan-apart was measured with the pad-coated surface mated against bond paper. This results in a lower fan-apart than if two pad-coated surfaces were in contact. This is due to the fan-out adhesive bonding to the outer face of the bond paper. A more satisfactory fan-apart would be expected to result at about 1-2% colloidal silica if both mating surfaces were pad-coated.

Table 10 - Effect of Colloid Addition on Pad-Coat Properties

wt. material	A	B	C	D	E
water	27.5	26.25	25.0	23.75	21.25
Nalco 1140 (40%)	0.00	1.25	2.50	3.75	5.00
PC 104	2.29	2.29	2.29	2.29	2.29
PC 60	0.16	0.16	0.16	0.16	0.16
PC 31	0.05	0.05	0.05	0.05	0.05
HEC Solution (g)	20.0	20.0	20.0	20.0	20.0
TOTAL wt (g)	50.0	50.0	50.0	50.0	50.0
Fan-apart	3.5	3.5	3.0	1.5	2.0
COF (Static)	0.32	0.373	0.517	0.62	0.717
Tape Test					
High Tack (#810)	85.%	--	--	80.%	40.%
Low Tack (#811)	15.%	--	--	5.%	2.%

Example 25

When the amount of abhesive silicone is increased to 3%, the relative amount of silica needed to obtain desired coefficients of friction and adhesion of toner powder would be expected to increase. Experiments run with 3% silicone, shown in Table 9, show that for this relatively high amount of silicone abherent increasing the amount of colloid permits satisfactory fan-apart while increasing the COF to a good value. Toner adhesion is also improved as shown by the reduction in the amount of toner removed. This is particularly evident in the Low Tack Tape Peel Test using 3m Scothc Brand #811 Magic tape its less aggressive adhesive.

Table 11 - Effect of Increase in Colloid on Properties at 3% Silicone Abhesive Concentration

Colloid Concentration	Fan-apart	COF	Tape #810	Test #811
0%	3.5	0.292	95%	30%
1%	3.5	0.449	--	--
2%	3.0	0.503	80%	3%
3%	3.5	0.558	80%	3%
5%	2.5	0.630	80%	1%

Example 26

A comparison of the effect of the thickener choice on the final coating performance is shown in Table 12. The comparison was made in formulations containing 2% silicone abherent with 1% colloid (Nalco 1140 colloidal silica).

Thus the choice of thickener will have an effect on the properties of the fan-apart, the coefficient of friction and the toner powder adhesion. In all cases the fan-apart as measured between the pad-coat and a 15# bond sheet is lower than would result if two pad-coated sheets were mated. The low coefficient of friction for the starch thickened coating indicates more colloid is needed to obtain a satisfactory result, and the toner adhesion results would also be improved by making this adjustment.

Table 12 - Comparison of Starch and HEC as Thickeners

	Starch (4.7%)	HEC (0.2%)	No Thickener
Fan-apart	3.0	2.5	2.5
COF	0.35	0.62	0.50
Tape peel test			
High Tack (Type #810)	98.%	80.%	85.%
Low Tack (Type #811)	85.%	5.%	12.%

Example 27

A direct comparison between a pad-coat using a silicone abherent and a pad-coat using a fluorochemical abherent was made. Both formulations contained 1% colloidal silica. The COF (coefficients of friction) of pad-coated surfaces against pad-coated surfaces were measured. The tape peel test employed 3M Scotch Brand #811 Magic Tape. Fan-apart was measured with the pad-coated surface facing a sheet of 15 pound bond paper. As noted previously, this configuration leads to fan-apart lower than that which would be found with tests performed with pad-coated surfaces facing each other. The results, shown in Table 13, demonstrate that a satisfactory result can be obtained with silicone abherent. In this example, the fluorochemical abherent provides better performance, however it should be noted that the silicone abherent was selected as being representative of the class and may well not be the optimum material for this application.

Table 13 - Comparison of Silicone and Fluorochemical Abherents

	Silicone Abherent	Fluorochemical Abherent
Wt% abherent	2.0	0.6
Fan-apart	2.5	3.5
COF	0.55	0.68
Low Tack Tape test	85.%	10.%

Reasonable modifications and variations are possible from the foregoing disclosure without departing from either the spirit or scope of the invention as defined in the claims.

Claims

1. A composition suitable for use as a pad-coat or release coating for carbonless paper constructions, said composition consisting essentially of about: (a) 0.1-10 weight percent inorganic colloid having a particle size in the range of about 1-125 nm; (b) 0.01-5.0 weight percent abherent material; (c) 60.0-99.9 weight percent water; and (d) 0-25 weight percent binder.

2. The composition according to Claim 1 wherein said inorganic colloid is at least one selected from the group consisting of silica, alumina, titania, zirconia, antimony pentoxide, and calcium carbonate colloids.

3. The composition according to Claim 1 wherein said inorganic colloid has a particle size range of from about 1 to 100 nm.

4. The composition according to Claim 1 wherein said abherent material is fluorinated.

5. The composition according to Claim 1 wherein abherent material is a polysiloxane.

6. A carbonless paper construction having a pad-coat or release coating applied over at least a portion of

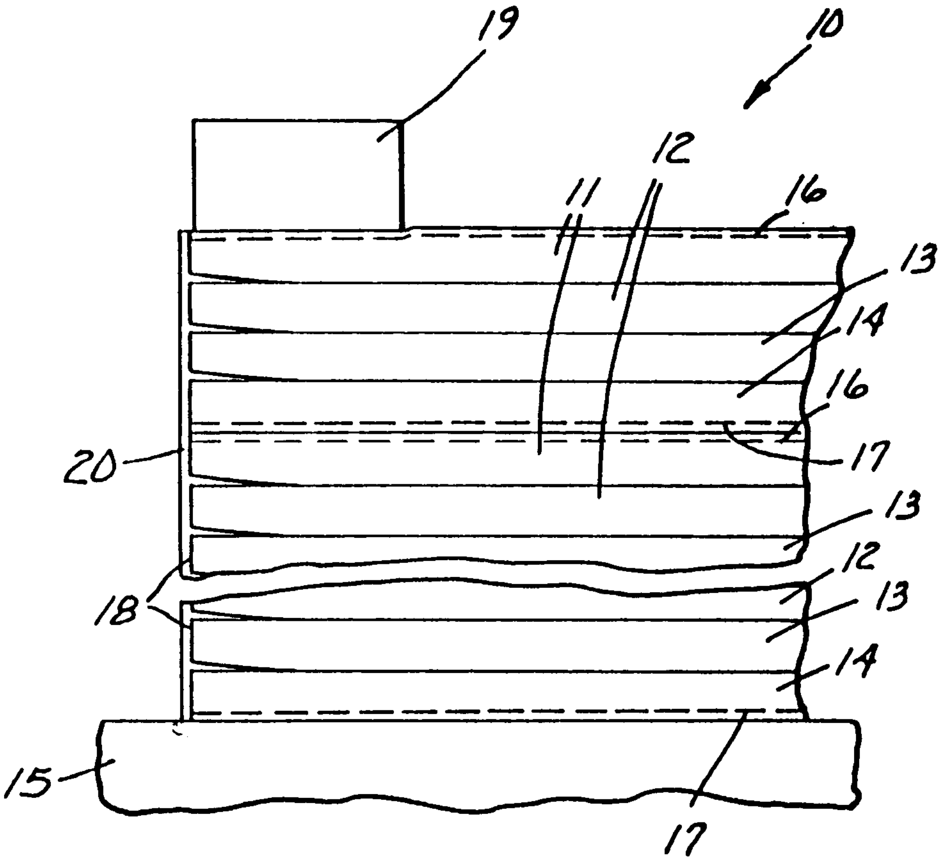
at least one outer surface of a carbonless paper construction, said pad-coat or release coating consisting essentially of: (a) 2.0-95.0 weight percent inorganic colloid having a particle size in the range of about 1-125 nm; (b) 2.0-75.0 weight percent abherent material; and (c) 0-95.0 weight percent binder.

7. The carbonless paper construction according to Claim 6 wherein said inorganic colloid is at least one selected from the group consisting of silica, alumina, titania, zirconia, antimony pentoxide, and calcium carbonate colloids.

8. The carbonless paper construction according to Claim 6 wherein said inorganic colloid has a particle size range of from about 1 to 100 nm.

9. The carbonless paper construction according to Claim 6 wherein said abherent material is fluorinated.

10. The carbonless paper construction according to Claim 6 wherein said abherent material is a polysiloxane.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