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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Iron Preparations for Intramuscular Injection.

We, AKTIEBOLAGET ASTRA, APOTEKARNES KEMISKA FABRIKER, a Swedish Body Corporate, of Sodertalje, Sweden, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to iron preparations suitable for intramuscular injection.

In certain states of iron deficiency, e.g. those that do not react satisfactorily to perorally administered iron or that do not tolerate such treatment, iron must be administered parenterally in order to obtain a sufficiently prompt therapeutic response. There are many iron preparations for intravenous injection on the market. One of these consists substantially of an aqueous solution of saccharated oxide of iron: another consists of an aqueous solution of a high molecular weight neutral complex of iron and a carbohydrate. When iron is injected intravenously, almost full use of the injected iron is obtained, but this method involves a considerable number of disadvantages, for example the injection itself must be carried out according to a special injection technique which requires great skill to avoid paravenous injection (i.e. injection outside the vein) in which case intense pain and lasting discoloration are caused. Another disadvantage is that the patient must not have bad or deep-lying veins. Occasionally other injuries, and even death caused by shock, have occurred as a result of the intravenous injection of a solution of saccharated oxide of iron.

Although the iron preparations for intravenous use may be adminstered intravenously without any series toxic effect, for various reasons they are unsuitable for intramuscular or subcutaneous injections. Thus, the saccharated oxide of iron mentioned above has a high osmotic pressure and basic reaction, which give rise to pain during injection, inflammation and unsatisfactory resorption.

At present there are only a few iron preparations on the market which are useful for intramuscular injection. One of these preparations contains as an active constituent a complex of low molecular weight dextran and iron. These preparations, however, have proved to give certain disadvantageous side effects, some of which are of a rather serious character. Thus in many cases, local discoloration of the skin surrounding the site of injection has been observed. The risk of discoloration may be reduced by the use of a special, rather complicated technique of injection comprising dislocation of the skin laterally prior to the injection so as to prevent the preparation injected into the muscle under pressure from trickling out through the perforation when the needle has been removed. This technique, however, is accompanied by a tendency for the injected preparation to trickle back and gather between the muscle and the skin. It also requires practice and experience and even when it is used, discoloration is obtained at the injection site in 25% of the treated cases (see Acta Medica Scandinavica Suppl. 342, Karlefors T. and Norden Å. "Studies on iron- dextran complex"), which is a substantial disadvantage. It has also been pointed out (by the same authors), that in some cases intramuscular injection of iron-dextran causes other side effects, such as fever, headache, nausea, vomiting and ague, especially on the fourth day of a treatment comprising daily injections. Moreover, it has been proved, by use of an iron-dextran preparation labelled with Fe^{59}, that the injected iron remains in the injection region for a very

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long time. Another fact which may be a serious disadvantage has been indicated by tests carried out by Richmond [see Brit. Med. Jl., (1959) p. 947, quoted in Sv. Läkartidning *57*, No. 5, pp. 289—290 (1960)]; Richmond has observed cancer at the injection sites on rats which have received intramuscular injections of iron-dextran solutions. The tests carried out by Richmond were repeated on mice by Haddow (see Ciba Foundation Symposium on Carcinogenesis, London 1959, pp. 300—306), and Haddow and Horning (J. Nat. Cancer Inst. 24 (1960) p. 109), who arrived at the same conclusion. The authors consider the iron-dextran complex to be carcinogenic, and that the retention of iron in the injection region seems to be of importance in this connection, since dextran of higher molecular weight, and consequently slower resorption than dextran with lower molecular weight, gives rise to more tumours.

The present invention provides a method for preparing an intramuscularly injectible iron preparation for use in human and veterinary medicine which is not subject to the drawbacks of the older preparations, gives very prompt resorption, is free from local reactions or injuries to the tissues and gives a good haematologic response. The preparation moreover has no tendency to cause sarcoma at the injection site even after repeated injections.

According to the invention there is provided a process for the production of a dry iron-containing composition which can be worked up into a preparation suitable for intramuscular injection in human and veterinary medicine which comprises mixing together in aqueous solution at least one soluble ferric salt of a physiologically innocuous acid, an α-hydroxy carboxylic acid and a hexitol component which is a hexitol, a uronic acid derivable from a hexitol or a hydroxyloweralkyl hexitol, or two or more of these, the α-hydroxy carboxylic acid and the hexitol component being physiologically innocuous and beng capable individually of forming complexes with ferric iron at *p*H 5—10; precipitating the iron-containing complex thus formed; and purifying and drying the precipitate.

The invention includes also liquid iron-containing preparations comprising an aqueous solution of a composition prepared by the process of the invention. The compositions are readily soluble at physiological pH values and are sufficiently stable for the solutions to be sterilised by autoclaving.

The iron must be in the trivalent form since ferrous compounds do not give the desired stability. Suitable ferric compounds include ferric chloride, which is preferred, ferric nitrate, sulphate, and acetate, and double salts, such for example as ferric ammonium sulphate.

The dry compositions preferably contain 5—30%, especially 12—16%, by weight, of iron and the injectible solutions preferably contain 5—60 milligrams of iron per millilitre, especially about 50 milligrams of iron per millilitre. It is, generally, desirable that the iron concentration in the injection solution should be as high as possible, in order that the injected volume may be small. In some cases, however, less concentrated preparations may be more suitable.

The hexitol component is preferably dulcitol, sorbitol, mannitol or iditol, or two or more of these, or a uronic acid or hydroxy loweralkyl hexitol derivable from dulcitol, sorbitol, mannitol or iditol, e.g. hydroxypropyl sorbitol, or two or more of these.

Particularly suitable α-hydroxy carboxylic acids are citric, gluconic, tartaric acid and malic acids. Lactic acid may also be used, but this acid has not quite as good properties as the other acids just mentioned.

The mixing of the ferric compound, α-hydroxycarboxylic acid and hexitol component preferably takes place in the presence of a water soluble dispersion stabiliser for the complex, usually a water-soluble carbohydrate. Dextrins containing a number of reducing groups corresponding to 40—200 milligrams of glucose, per gram of dextrin, are preferred because of their good compatibility in the organism, but other water soluble carbohydrates may conveniently be used, e.g. glucose, saccharose or low molecular weight dextran fractions.

Although the molecular size and structure of the active iron complex present in the composition has not been fully determined, it is probable that the composition contains a complex in which both the hydroxy carboxylic acid component and the hexitol component are bonded directly to the iron atom, and that the preparation forms a low molecular weight dispersion in water, with a mean molecular weight exceeding 5,000.

The particle size of the new iron compositions should preferably be such that at least the major part (i.e. at least 50%), and especially more than 90%, by weight of the particles have a sedimentation constant less than 17×10^{-13} sec., preferably less than 14×10^{-13} sec., the sedimentation constant being determined in a physiological saline solution containing 1 milligram of iron per millilitre in an ultra centrifuge 900 seconds after the rotor has attained a constant speed of 59,780 revolutions per minute. The sedimentation constant is independent of the nature of the centrifuge. By electrophoresis of a solution of the composition, the latter can be divided into three iron-containing constituents at least two of which contain the iron in complex form and migrate slowly

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towards the anode. The most rapidly migrating of said two migrating iron complex constituents, which amounts to about 6% of the total iron complex, is dialysable.

In a modication of the invention the iron-containing complex formed by mixing the ferric salt, the α-hydroxycarboxylic acid and the hexitol component is worked up *in situ* into a preparation suitable for intramuscular injection in human and veterinary medicine. Usually, however, it is preferred to prepare the dry composition first and then to make the preparation as required, autoclaving the dispersion to sterilise it before use. By use of the latter procedure, storage of the preparation for a long period of time is made possible, since the dry composition is very suitable for storage.

The dry composition can for instance be prepared in the following way. An aqueous solution of the ferric compound is added, preferably with stirring, to an aqueous solution, which may be at a temperature of 18—100° C., preferably 50—70° C., containing the hexitol-component (e.g. 2—20%) and the carboxylic acid (e.g. 1—10%) and, if required, the physiologically innocuous dispersion stabilizer (e.g. 20—40%). (Except where otherwise stated, all proportions in this Specification are by weight.) The ferric compound is preferably added in amount sufficient to provide at the most 35 moles, preferably at least 1 mole, of ferric compound per mole of hexitol-component. The ferric compound is preferably added in portions and the *p*H of the solution adjusted to 5—10, preferably 7, after the addition of each portion.

After cooling of the mixture to ambient temperature, precipitation is effected, preferably by adding alcohol or another non-solvent for the complex, e.g. in an amount two to four times the volume of the mixture. The precipitate formed is separated, purified by repeated solution, precipitation and washing, and finally dried. If the solution is to be used directly, the complex is not precipitated and the solution is sterilised before it is used.

During purification of the precipitate, resolution is conveniently carried out with water mixed with a small amount of the complex-forming hydroxy-carboxylic acid. When solution is complete, the *p*H is again adjusted to 5—10, preferably 7.3 to 7.7. The solution so formed is heated to about 60° C., and the precipitate is added thereto while stirring. As washing liquid for the precipitate alcohol is conveniently used.

The purification is necessary in order to obtain a sufficient degree of purity for intramuscular injection without any risk of side effect. After the purification process, the preparation obtained can be desiccated, preferably *in vacuo*.

When preparing an injection solution a certain amount of the hexitol-component is preferably added to the distilled water used to make the solution. An amount less than 165 milligrams per millilitre of solution is generally satisfactory. This additional amount of hexitol-component is useful because some of the hexitol-component is lost during the different purification stages in preparing the dry preparation. Thus an injection solution can be made by preparing an aqueous solution containing 70—110 grams of hexitol-component per litre of solution, heating the solution to about 60° C. while stirring and then adding the dry preparation in portions while stirring is continued until the solution attains the desired concentration of iron. When all the dry preparation has been added, the solution is kept at 60° C. for another hour while the stirring is continued. Then, the *p*H of the solution is adjusted to 8.0 to 8.4, preferably to 8.2, and the solution is cooled to ambient temperature, filtered, dispersed and sterilized in an autoclave at 120° C. for about 20 minutes. A typical preparation contains per millilitre the equivalent of 10 to 300 milligrams of the hexitol-component, 10 to 70 milligrams of the α-hydroxy carboxylic acid and 150 to 350 milligrams of the water-soluble dispersion stabiliser.

Certain of the iron compositions obtainable by the process of the invention are new compositions of matter and as such form part of the present invention. These new compositions are (1) those in which the α-hydroxycarboxylic acid is one or more of citric, tartaric and malic acids, and (2) those in which the hexitol-component is a uronic acid derivable from a hexitol or a hydroxy lower alkyl hexitol.

According to experiments carried out the degree of absorption attained seems to be independent of the *p*H value of the injection solution prior to autoclaving, provided that this *p*H is between 5 and 10. It has been ascertained that the *p*H of the injection solution changes during the autoclaving in a way such that the high *p*H values decrease and low *p*H values increase. In order to obtain a *p*H value of about 7.5, i.e. the *p*H value in the musculature and blood, the *p*H of the injection solution prior to the autoclaving should be between 8.0 and 8.4. A *p*H value of 8.2 has proved to be especially suitable.

Extensive investigations have been carried out to find out the properties of the preparations under the conditions of use, and at the same time the preparations have been subjected to pharmacological and clinical investigations.

Precipitation tests have proved that the preparation is fully sable at the *p*H value of the blood. No haemolytic effect has been indicated. The effect of the preparation on

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the coagulation of the blood has been determined *in vivo* in rabbits in doses corresponding to the therapeutic doses for man, as well as *in vivo* in man; no effect on the coagulation was observed within one hour after the injection.

The acute toxicity of the preparation was determined by subcutaneous and intravenous administration to white mice. Male animals with a weight of 17—24 grams were used. The concentrations of the injected solutions, which were diluted with physiological saline solution, correspond to 0.5% iron. The number of animals in each test was between 120 and 160: 420 animals were used in all. The observation period was 7 days. The LD50 (medial lethal dose) in subcutaneous administration corresponded to 36 milligrams per kilogram body weight, in intraperitoneal adminstration to 50 milligrams per kilogram body weight and in intravenous administration to 35 milligrams per kilogram body weight. There was no statistically significant difference between these three routes of administration. The toxicity was also determined by intramuscular administration in rats and intramuscular and intravenous administration in rabbits, and the obtained values of LD50 were of the same magnitude as the doses for mice.

No antigenic properties have been observed, which is of practical importance, since the undesired systemic reactions reported with the older preparations probably are of allergic origin.

The transport of iron from the site of injection was examined after the injection of solutions of the preparation as well as after injection of solutions containing a commercial iron-dextran complex. Deep intragluteal injections were made in doses of 20 milligrams Fe (0.4 millilitre) per kilogram body weight in rabbits weighing 2—3 kilograms. At different times after the injections the animals were killed and the gluteal muscles dissected from the leg. Musculature and skin around the injection site were wet oxidized with sulphuric acid and nitric acid, and the iron content was then determined by means of a colorimetric rhodanide method. It was found that the preparation was absorbed very rapidly, 70% of the iron supplied having been removed from the injection site only 3 hours after the injection, whereas in the same time only 5% of the commercial iron-dextran complex was absorbed. The so-called "rapid absorption phase" of the preparation of the invention was complete after about 24 hours, when about 15% of the injected iron was left at the injection site, whereas this phase for the commercial iron-dextran complex was still incomplete after about 72 hours, when about 20% of the iron remained in the muscle (see Fig. 1 of the accompanying drawings, in which the percentage of iron absorbed is plotted against time.).

The iron content of serum was determined in experiments with rabbits at different times after the intramuscular injection of the preparation of the invention and of iron-dextran in doses of 1.5 milligrams of iron per kilogram body weight. Deep intragluteal injections were made and then blood samples were taken from the border vein of the ear. The iron content in 1 cc. of the serum was determined principally by the method described by Heilmeyer and Plötner (1937). The results are seen in Fig. 2, of the drawings in which the amouunt of iron in milligrams per 100 cc. of serum is plotted against the interval of time after the injection in hours. As may be seen the resorption of intramuscularly injected iron from the preparation according to the invention is very rapidly reflected in an increase of the iron in the serum. With the iron dextran complex an increase of the serum iron is also obtained, but the maximum values are not reached until after at least 6 hours. In order to investigate the conditions during the first hour after the injection in more detail, more blood samples were taken in another test during this time. The results are shown in Fig. 3 of the drawing, from which it appears that the maximum iron level of the serum with the preparation according to the invention was reached after only about 20 minutes and that this maximum value remained unchanged for about another 30 minutes after the injection. The values determined after the injection of the iron-dextran preparation did not show any appreciable increase during this period of time.

Corresponding tests have also been carried out with the preparation of the invention in man and the results of these tests are shown in Figure 4 of the drawings. 25, 50 and 100 milligrams of iron were given deep intramuscularly in the gluteal area of 12 healthy persons. Blood samples from the vein were taken before, and at varying periods after the injections. As is apparent from the graphs the iron content of the serum increased immediately after the injection, reached its maximum after about 2 hours and then decreased gradually.

Tests were also carried out in man in order to determine the unsaturated iron binding capacity of the serum (UIBC), a method published by Cartwright and Wintrobe (1949) being employed. The results show that the UIBC was decreased as a consequence of the injections. The iron-binding capacity of the transferring was most pronounced after doses of 50 and 100 milligrams. The preparation of the invention thus contains an iron component of such properties that it can react immediately with

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transferrin, and it differs in this respect also from commercial iron-dextran.

In order to determine the tolerance of the preparation, its therapeutic effect and possible side effects, clinical investigations have been carried out in which the preparation has been compared with a solution containing iron-dextran. Both preparations contained 50 milligrams of iron per cc. and were given deep intramuscularly in the gluteal region in doses of 100 milligrams of iron per injection. The injections were given daily on alternating sides over a period of 10 days (total 1000 milligrams iron). The sample consisted of 65 patients with conventional clinical criteria for stabilised iron deficiency and very varying degrees of anaemia. For the evaluation of the therapeutic effect, the sample was therefore divided into three sub-groups. Every other patient was treated with the preparation of the invention and the rest with iron-dextran. In these investigations the Hb-values (haemoglobin value), erythrocyte count, reticulocyte count, and serum iron were determined and the sedimentation rate, urinary sediment, non-protein nitrogen and liver and renal functions were continuously checked. The therapeutic effect was evaluated by determination of reticulocyte count and increases of haemoglobin and serum iron. The values obtained for reticulocyte count, haemoglobin increase and increase of serum iron were substantially identical for both of the preparations in the three sub-groups of patients.

During the time of investigation, side effects such as rise in temperature, nausea, vomiting and ague were also recorded.

In the group of 35 patients treated with iron-dextran, in one patient a systemic reaction consisting of a temperature rise to 38.2° C. was noted after the last injection. Another patient had to discontinue the treatment owing to the intense local reactions at the injection site combined with a general feeling of illness and temperature increase to about 38° C. Besides these two patients, six others reported pain not only at the injection site, but throughout the thigh; four of these were obliged to rest and two of them even had to stay in bed for a couple of days. In these two last-mentioned cases, the buttocks and thighs showed a pronounced reddening and intense tenderness though local discoloration of the skin at the injection site was not observed; this may have been due to the fact that the dose of iron was low (100 milligrams per injection). Systematic reactions were thus observed in about 23% of the patients treated with iron-dextran.

In the group of patients treated with the preparation of the invention, a slight local reaction was observed in 5 of 40 of the patients immediately after the injection; this showed itself in a feeling of tension and a moderate tenderness on palpation at the injection site, and was probably due to the hypertonic effect of the preparation. The tenderness diminished in a short time and was comparable with the feeling after an intramuscular vitamin or penicillin injection. In no case, was the reaction such that the treatment had to be discontinued. No discoloration of the skin or sign of local irritation was observed in any case. Two patients outside this sample batch tolerated the preparation in spite of very reduced renal functions.

Summing up, it has thus been ascertained that the absorption of the new preparation from the muscle is very rapid, substantially more so than that of iron dextran. The good absorption is reflected in an increase of iron in the serum, which is substantial after only 5 minutes and after about 20 minutes has reached a maximum, whereas the iron-dextran does not reach its maximum until after many hours. The iron-dextran is thought to be absorbed through the lymphatic vessels and to be independent of the local focus of inflammation caused by it at the injection site (so-called reactive absorption). It is probable that the high molecular weight constituents of the preparation, which, however, have considerably lower molecular weight than the iron-dextran, are also absorbed lymphatically to a certain degree, while the low molecular weight constituent may be absorbed through the blood vessels also. The main part of the iron in the preparation is present as constituents which are absorbed immediately, without the need of any local inflammatory irritation process to be started first and this may be due to the molecular weight being lower than that of the iron-dextran. Besides these iron constituents, the new preparation contains also a small amount of dialysable iron which has the capacity of forming complexes with transferrin. This dialysable iron is of special importance since the iron-transferrin complex can be used directly in the erythropoiesis; the higher molecular constituents may be absorbed by the recticuloendothelial system for further rearrangement and metabolism.

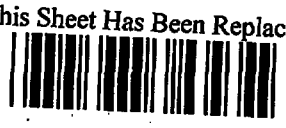
The invention is illustrated by the following examples.

EXAMPLE I.

Preparation of dry composition.

30 cc. of 70% (by volume) sorbitol were dissolved in 225 cc. of distilled water, after which 75 grams of dextrin were added and the mixture was heated to 60° C. while stirring. On solution of the dextrin, 10.5 grams of crystallised citric acid were added. 45 grams of sodium hydroxide were dissolved in 225 cc. of distilled water (solution III) and from this solution 22.5 cc. were added to

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the first-mentioned solution of sorbitol, dextrin and citric acid (solution I). Then solution II, which contained 84 grams of ferric chloride hexahydrate dissolved in 115 cc. distilled water, was added to solution I in 8 portions while solution I was stirred and kept at a temperature of 60° C. After each of these additions, the reaction mixture was neutralised with 23 cc. of solution III. The time for each addition was one minute. After the eighth neutralisation the *p*H was 6.95. This was adjusted to 8.2 by addition of 7.3 cc. of solution III. The solution was heated with stirring for a further 30 minutes, and then cooled to 30° C. and diluted to a volume of 675 cc. with distilled water.

To the diluted solution 2025 cc. of 83% (by volume) ethanol was added while the solution was stirred and the stirring was continued for a further 5 minutes. When the precipitate formed had settled, the mother liquor was decanted and the precipitate was washed with 150 cc. of 66% ethanol. The washed precipitate was dissolved at a temperature of 60° C. in 450 cc. of distilled water containing 3 grams of crystallised citric acid, after which the *p*H was adjusted to 8.2 with 2 cc. of solution III. After half an hour the solution was cooled to 30° C. and was filtered through double filter papers and diluted to a volume of 675 cc. with distilled water.

To the filtered solution 2025 cc. of 83% ethanol were added while the solution was stirred. The stirring was continued for 10 minutes after which the precipitate formed was allowed to settle. After 20 minutes the mother liquor was poured off. The precipitate was washed twice with 63% ethanol and three times with undiluted ethanol, and then dried *in vacuo* at a temperature of 45—50° C. 100 grams of the dry preparation with an iron content of 16.1% were obtained.

The preparation of injection solution.

15 cc. of 66.7% aqueous sorbitol solution were dissolved in 105 cc. of distilled water and heated to 60° C. 47.0 grams of the dry preparation prepared by the above method were added in portions with stirring, after which the mixture, while still being stirred, was kept at 60° C. for a further hour. The *p*H of the solution was 7.85. The solution was cooled to room temperature and then diluted with distilled water to a volume of 150 cc. The diluted solution was filtered through a thin layer of refined filtering aid (Theorit No. 3) on double filter paper in a Nutsche (a type of suction filter). The filtered solution was filtered again through a Celas filter under sterile conditions, and dispensed in ampoules, which were then sterilised in an autoclave at 120° C. for 20 minutes. The sterilised iron solutions had a total iron content of 51.2 milligrams per cc., a *p*H value of 7.4, a viscosity of 9.6 centipoises at 20° C. and a freezing point depression of 2.44° C.: they were sterile, non-pyrogeneous and gave an absorption of 86% on rabbit after injection of a dose of 20 milligrams of iron per kilogram body weight.

EXAMPLES II—VII.

Absorption tests with varying contents of the hexitol in the dry preparation were carried out, no further addition of hexitol being made during the preparation of the injection solution. Otherwise the process was identical with that described in Example I. The results are shown in the following table:

TABLE I.

	Millilitres of 70% sorbitol per kilogram of dry preparation	Absorption from the rabbit muscle %
II	34	43
III	100	47
IV	155	62
V	300	72
VI	557	74
VII	260 grams of pulverised anhydrous sorbitol	81

EXAMPLE VIII.

A dry preparation was made in the way decribed in Example I, except that citric acid was added in an amount corresponding to a content of 28.9 grams per kilogram of dry preparation and that the base and the iron were added in portions, the iron solution being added prior to the base. When all the iron and base had been added, the *p*H was adjusted to 9.9. After the first precipitation with 4 volumes of ethanol the precipitate was redissolved in pure water. After solution in distilled water, reprecipitation with ethanol, washing and drying, a dry preparation was obtained from which an injection solution was made in the way described in Example I, a further addition of sorbitol corresponding to 100 cc. of a 70% aqueous sorbitol solution per litre of injection solution being made. This solution gave an absorption from rabbit muscle of 49%.

EXAMPLE IX.

A dry preparation was made in the way described in Example VIII except that 71.7 grams of citric acid were added per kilogram of dry preparation and the *p*H value was adjusted to 8.2 in the reaction mixture after the addition of the ferric compound. Then a sterile injection solution was made in the way described in Example VIII from the dry preparation obtained. This injection

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solution had an absorption of 78% from rabbit muscle.

EXAMPLE X.

A dry preparation was made in the way set forth in Example IX, except that 97.7 grams of citric acid were added per kilogram of dry preparation. A sterile injection solution was prepared from the dry preparation in the way described in Example VIII and gave an absorption from rabbit muscle of 81%.

EXAMPLE XI.

A dry preparation was made in the way set forth in Example IX, except that 100 grams of citric acid per kilogram of dry preparation were added to the reaction mixture, and that when the precipitate was redissolved prior to reprecipitation, a further 28.7 grams of citric acid per kilogram of dry preparation were added. A sterile injection solution prepared in the way described in Example VIII gave an absorption of 92% from rabbit muscle.

EXAMPLE XII.

A dry preparation was made in the way described in Example IX, except that 92.3 grams of citric acid per kilogram of dry preparation were added to the reaction mixture, and that when the precipitate was redissolved prior to reprecipitation a further 92.3 grams of citric acid were added per kilogram of dry preparation. A sterile injection solution made in the way described in Example VIII gave an absorption of 94% from rabbit muscle.

EXAMPLE XIII.

A dry preparation was obtained in the following way. 21.0 grams of mannitol and 75.0 grams of dextrin were dissolved in 225 cc. of distilled water. On solution of these two ingredients at 60° C. 10.5 grams of citric acid were added. To the solution formed 22.5 cc. of a solution containing 45.0 grams of sodium hydroxide in 225 cc. of distilled water were added. Then, 84.0 grams of ferric chloride hexahydrate dissolved in 115 cc. of distilled water were added in eight portions. After the addition of each portion 23 cc. of the sodium hydroxide solution were added to the reaction mixture. On completion of the addition of iron and base the *p*H of the reaction mixture was adjusted to 8.25. The reaction mixture was kept at 60° C. for a further period of about 30 minutes, after which the mixture was cooled to room temperature, diluted to 675 cc. and mixed with 2.7 litres of 83% ethanol. After the precipitate had settled the mother liquor was removed and the precipitate was treated with 150 cc. of ethanol diluted to the same concentration as the mother liquor. The precipitate was sucked dry on a Nutsche after which it was dissolved, with stirring at a temperature of 50° C., in 450 cc. of distilled water containing 3 grams of crystallised citric acid. The *p*H value was adjusted to 8.3 and the heating was continued for some minutes. Then the solution was cooled to 30° C., filtered, diluted to 675 cc. and again precipitated with 2.7 litres of 83% ethanol. After half an hour, the mother liquor was sucked off and the precipitate was washed twice with 150 cc. of alcohol solution of the same concentration as the mother liquor and three times with undiluted ethanol. The washer precipitate was dried for 15 hours *in vacuo* at a temperature of 45—50° C. The yield was 110 grams of the dry preparation, which had a total iron content of 15.9%.

47.0 grams of the dry preparation obtained were added in portions to a solution of 10.5 grams of mannitol in 105 cc. of distilled water at a temperature of 65° C. while stirring. After one hour the solution obtained was cooled to room temperature and diluted with distilled water to 150 cc. The solution was then filtered through filter paper and a sterile filter and dispensed in ampoules which were sterilised in an autoclave at a temperature of 120° C. for 20 minutes. The solution, which was ready for injection, had a total iron content of 48.3 milligrams per cc. and a *p*H of 7.65, and gave an absorption of 75% from rabbit muscle.

EXAMPLE XIV.

A dry preparation was obtained in the following way, 7.0 grams of crystallised dulcitol and 25.0 grams of dextrin were dissolved in 75 cc. of distilled water at 45° C; 3.5 grams of citric acid were then added. To the solution formed 7 cc. of a solution of 15.0 grams of sodium hydroxide in 75 cc. of distilled water were added. Then a solution of 28.0 grams of ferric chloride hexahydrate dissolved in 38 cc. of distilled water was added in 8 portions with stirring and continued heating. After the addition of each portion 7.5 cc. of the sodium hydroxide solution were added to the reaction mixture. On completion of the addition of ferric chloride and base, the *p*H of the reaction mixture was adjusted to 8.25. The mixture was kept at a temperature of 45° C. for a further 30 minutes, after which it was cooled to room temperature, diluted to 225 cc. and mixed with 900 cc. of 83% ethanol. On settling of the precipitate, the mother liquor was removed and the precipitate was then treated with 50 cc. of ethanol diluted to the same concentration as the mother liquor. The precipitate was sucked to dryness on a Nutsche and was then dissolved at a temperature of 60° C. in 150 cc. of distilled

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water containing 1.0 gram of crystallised citric acid. The *p*H value was adjusted to 8.3 and the heating was continued for some minutes. The solution was then cooled to 30° C., filtered, diluted to 225 cc. and again precipitated with 900 cc. of an 83% alcohol solution. After half an hour the mother liquor was sucked off and the precipitate was washed twice with an alcohol solution of the same concentration as the mother liquor and three times with undiluted ethanol. The washed precipitate was dried for 15 hours *in vacuo* at a temperature of 45—50° C. It had a total iron content of 14.9%.

17.0 grams of the dry preparation thus obtained were added with stirring to a solution of 3.5 grams of dulcitol in 40 cc. of distilled water at a temperature of 60° C. After one hour, the solution formed was cooled to room temperature and diluted with distilled water to a volume of 50 cc. After filtering through filter paper and a sterile filter the solution was dispensed in ampoules, which were sterilised in an autoclave at a temperature of 120° C. for 20 minutes. The solution, which was ready for injection, had a total iron content of 55.3 milligrams per cc. and a *p*H value of 7.6 and gave an absorption of 75% from rabbit muscle.

EXAMPLE XV.

A dry preparation was made in the following way. 30 cc. of a 70% aqueous sorbitol solution and 75.0 grams of purified dextrin were dissolved in 225 cc. of distilled water at 60° C.; 52.2 grams of a 50% aqueous solution of gluconic acid were then added. The solution formed was mixed with 22.5 cc. of a solution of 50.0 grams of sodium hydroxide in 250 cc. of distilled water. While continuing the stirring and heating, 200 cc. of the sodium hydroxide solution were added in 8 portions. On the completion of the addition of the base 1/8 of a solution of 84.0 grams of ferric chloride hexahydrate in 115 cc. of distilled water was added. The *p*H value was adjusted to 8.3 and the reaction mixture was kept at 60° C. for one hour while stirring. Then the solution was cooled to 30° C. and mixed with 2720 cc. of 83% ethanol while stirring. After one hour the mother liquor was sucked off and the precipitate obtained was washed on a Nutsche with 150 cc. of ethanol of the same concentration as the mother liquor. The washed precipitate was dissolved at a temperature of 60° C. in 450 cc. of distilled water containing 8.4 grams of gluconic acid and the *p*H was adjusted to 8.1. After half an hour the solution was cooled to 30° C., filtered and diluted with distilled water to a volume of 750 cc. The diluted solution was mixed with stirring with 3000 cc. of 83% ethanol and then the mother liquor was poured off. The precipitate obtained was mixed with 150 cc. of diluted alcohol of the same concentration as the mother liquor and was left overnight. The mother liquor was then sucked off and the precipitate was washed twice with 150 cc. of diluted ethanol of the same concentration as the mother liquor and three times with 150 cc. of undiluted ethanol. The washed precipitate was dried for 12 hours at 45—50° C. *in vacuo*. The product obtained had an iron content of 13.5%.

56.0 grams of the dry preparation obtained were added in portions with stirring to a solution of 15 cc. of a 70% aqueous sorbitol solution in 105 cc. of distilled water at a temperature of 60° C. After one hour at 60° C. the solution was cooled to room temperature and diluted with distilled water to a volume of 150 cc. The diluted solution was filtered, dispensed in ampoules and sterilised in an autoclave at a temperature of 120° C. for 20 minutes. The sterilised solution had a total iron content of 51.1 milligrams/cc., a *p*H value of 7.65 and gave an absorption of 87% from rabbit muscle.

EXAMPLE XVI.

A dry preparation was obtained in the following way. 30 cc. of a 70% aqueous sorbitol solution and 75.0 grams of dextrin were added to 225 cc. of water. On solution of these constituents at 60° C., 11.3 grams of tartaric acid (molecular weight 150.05) were added. To the solution formed, 40 cc. of a solution of 50.0 grams of sodium hydroxide in 250 cc. of distilled water were added. Then 184 cc. of the above base were added in 8 portions. After the addition of each portion 1/8 of a solution of 84.0 grams of ferric chloride hexahydrate in 115 cc. of distilled water was added. On completion of these additions the *p*H was adjusted to 9.2 and the stirring and heating were continued for another hour. Then the solution was cooled to 30° C. and filtered. To the filtered solution, 2700 cc. of 83% ethanol were added while stirring. After one hour the mother liquor was poured off and the precipitate obtained was washed with 150 cc. of ethanol of the same concentration as the mother liquor. The washed precipitate was dissolved at 60° C. in 450 cc. of distilled water containing 3.9 grams of tartaric acid. The solution formed was stirred for half an hour at 60° C. and was then cooled to 30° C., filtered and diluted with distilled water to a volume of 675 cc. The diluted solution was mixed with 2700 cc. of 83% ethanol while stirring. After half an hour the mother liquor was sucked off and the precipitate was washed twice with 150 cc. of ethanol of the same concentration as the mother liquor and three times with 150 cc. of undiluted ethanol and was dried *in vacuo* at 45—50° C. for 12

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hours. The dried precipitate had an iron content of 14.5%.

53.0 grams of the dry preparation obtained were added in portions to a solution of 15 cc. of 70% sorbitol in 105 cc. of distilled water at 60° C. while stirring. The solution formed was stirred for one hour at this temperature and was then cooled to room temperature, diluted with distilled water to a volume of 150 cc., and filtered. After having been sterilised in an autoclave at a temperature of 120° C. for 20 minutes the solution, which was ready for injection, had a *p*H value of 8.27 and a total iron content of 51.6 milligrams per cc. It gave an absorption of 62% from rabbit muscle.

EXAMPLE XVII.

A dry preparation was obtained in the following way. 30 cc. of a 70% aqueous sorbitol solution and 75.0 grams of dextrin were added to 225 cc. of water. On solution of these constituents at 60° C., 10.0 grams of malic acid were added. To the solution obtained 22.5 cc. of a solution of 50.0 grams of sodium hydroxide in 250 cc. of distilled water were added. Then a solution of 84.0 grams of ferric chloride hexahydrate in 150 cc. of distilled water was added in 8 portions. After the addition of each portion the reaction mixture was neutralised with 23 cc. of the sodium hydroxide solution. After the eighth neutralisation the *p*H was adjusted to 8.2 and stirring was continued at 60° C. for half an hour, after which the solution was cooled to 30° C. and diluted to a volume of 675 cc with distilled water. To the diluted solution 2700 cc. of 83% ethanol were added while stirring. After one hour the mother liquor was poured off and the precipitate obtained was washed with 150 cc. of ethanol of the same concentration as the mother liquor. The washed precipitate was dissolved at 60° C. in 450 cc. of distilled water containing 3.0 grams of malic acid and the *p*H was adjusted to 8.2. After stirring for half an hour at 60° C. the solution formed was cooled to 30° C., filtered and diluted with distilled water to a volume of 750 cc. The diluted solution was mixed with 3000 cc. of 83% ethanol while stirring. After half an hour the mother liquor was poured off and the precipitate obtained was washed twice with 150 cc. of ethanol of the same concentration as the mother liquor and three times with 150 cc. of undiluted ethanol and was dried *in vacuo* at 45—50° C. for 12 hours. The dried precipitate had an iron content of 15.2%.

50.0 grams of the dry preparation thus obtained were added in portions to a solution of 15 cc. of 70% sorbitol in 105 cc. of distilled water at 60° C. while stirring. After stirring for one hour at this temperature the solution formed was cooled to room temperature, diluted with distilled water to a volume of 150 cc., and filtered. After sterilisation at 120° C. for 20 minutes in an autoclave the solution, now ready for injection, had a *p*H of 7.4 and a total iron content of 54.6 milligrams/cc. It gave an absorption of 69% from rabbit muscle.

EXAMPLE XVIII.

By a procedure analogous to that of Example I, injection solutions with an iron content of 50 milligrams/cc. were prepared, using as the ferric compound first ferric ammonium sulphate and second ferric sulphate. Absorption from rabbit muscle was 66% for the preparation made using ferric ammonium sulphate and 77% for that made using ferric sulphate.

EXAMPLE XIX.

A dry preparation of ferric chloride, sorbitol, citric acid and glucose was prepared, using a procedure analogous to that of Example 1, except that only one precipitation with alcohol was carried out. From the dry preparation an injection solution was made containing 52.1 milligrams of iron per cc. of solution. This gave an absorption from rabbit muscle of 69%.

EXAMPLE XX.

A dry preparation of ferric chloride, sorbitol, citric acid and saccharose was prepared using a procedure analogous to that of Example I. From the dry preparation an injection solution containing 57.3 milligrams of iron per cc. solution was made. This gave an absorption from rabbit muscle of 89%.

EXAMPLE XXI.

A dry preparation of ferric chloride, sorbitol, citric acid and dextran with a content of reducing groups per gram corresponding to 275 milligrams of glucose was preparted using a procedure analogous to that of Example I. From the dry preparation an injection solution containing 50.1 milligrams of iron per cc. was made. This gave an absorption from rabbit muscle of 88%.

EXAMPLE XXII.

A dry preparation of ferric chloride, sorbitol, citric acid and dextrin was prepared using a procedure analogous to that of Example I. An injection solution containing 52.1 milligrams of iron per cc. was made from the dry preparation substantially as set forth in Example I, but besides sorbitol a further amount of citric acid corresponding to 5 grams per litre of injection solution was added. This injection solution gave an adsorption of 87% from rabbit muscle.

EXAMPLE XXIII.

A dry preparation was prepared by dis-

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solving 25 cc. hydroxypropyl-sorbitol (Atlas Powder Company No. G-2401) and 75.0 grams of dextrin in 225 cc. of distilled water. On solution of these constituents at 60° C., 10.5 grams of citric acid were added. To the solution formed 22.5 cc. of a solution of 45.0 grams of sodium hydroxide in 225 cc. of distilled water were added. Then 84.0 grams of ferric chloride hexahydrate dissolved in 115 cc. of distilled water were added in 8 portions. After each portion of ferric compound, 23 cc. of the above sodium hydroxide solution were added. When the addition of ferric compound and sodium hydroxide was finished the *p*H of the reaction mixture was adjusted to 8.15. The mixture was kept at the temperature of 60° C. for another 30 minutes, after which it was cooled to room temperature, and diluted to 675 cc. with distilled water. Then 2025 cc. of 83% ethanol were added. After the sedimentation of the resulting precipitate the mother liquor was separated. The precipitate obtained was treated with 150 cc. of ethanol of the same concentration as the mother liquor and then dried on a Nutsche. It was then dissolved at 60° C. with stirring in 450 cc. of distilled water containing 3.0 grams of crystallised citric acid. The *p*H of the solution was adjusted to 8.2 and heating was continued for some minutes. The solution was then cooled to 30° C., filtered and diluted to 675 cc. with distilled water and once more precipitated with 2025 cc. of 83% alcohol. After half an hour the mother liquor was separated and the precipitate washed twice with 150 cc. of alcohol of the same concentration as the mother liquor and 3 times with concentrated alcohol. The washed precipitate was dried 15 hours *in vacuo* at a temperature of 45—50° C. Yield: 97.4 grams of a preparation with a total iron content of 15.3%.

49.0 grams of the dried preparation were added in portions to a solution of 12.5 ml. hydroxypropyl-sorbitol in 105 cc. of distilled water at 60° C. while stirring. After 20 minutes the *p*H of the solution was adjusted to 8.2 with sodium hydroxide. After 1 hour the solution obtained was cooled to room temperature and diluted with distilled water to a volume of 150 cc. After filtering through filter paper and a sterile filter the solution was dispensed in ampoules, which were sterilised in an autoclave at 120° C. for 20 minutes. The prepared injection solution had a total iron content of 54.0 mg/cc. and a *p*H of 7.1. It gave an absorption of 84% from rabbit muscle after 7 days.

WHAT WE CLAIM IS:—

1. Process for the production of a dry-iron-containing composition which can be worked up into a preparation suitable for intramuscular injection in human and veterinary medicine which comprises mixing together in aqueous solution at least one soluble ferric salt of a physiologically innocuous acid, an α-hydroxy carboxylic acid and a hexitol component which is a hexitol, a uronic acid derivable from a hexitol or a hydroxy-lowerakyl hexitol, or two or more of these, the α-hydroxy carboxylic acid and the hexitol component being physiologically innocuous and being capable individually of forming complexes with ferric iron at *p*H 5—10; precipitating the iron-containing complex thus formed; and purifying and drying the precipitate.

2. Process according to Claim 1 wherein the α-hydroxycarboxylic acid is one or more of citric, gluconic, tartaric and malic acids.

3. Process according to Claim 1 or 2 wherein the hexitol component is mannitol, dulcitol, sorbitol, iditol, or hydroxypropyl sorbitol, or two or more of these.

4. Process according to Claim 1 or 2 wherein the hexitol component is a uronic acid or hydroxyloweralkyl hexitol derivable from dulcitol, sorbitol, mannitol or iditol, or two or more of these.

5. Process according to Claim 1 or 2 wherein the α-hydroxycarboxylic acid is citric acid and the hexitol component is sorbitol.

6. Process according to any one of the preceding claims wherein the soluble ferric compound is ferric chloride.

7. Process according to any one of Claims 1 to 5 wherein the soluble ferric compound is ferric nitrate, sulphate or acetate.

8. Process according to any one of Claims 1 to 5 wherein the soluble ferric compound is ferric ammonium sulphate or other double salt.

9. Process according to any one of the preceding claims wherein the *p*H of the aqueous solution is front 5 to 10 and the complex is precipitated by the addition of a non-solvent for the complex.

10. Process according to Claim 9 wherein the *p*H is from 8.0 to 8.4.

11. Process according to Claim 9 or 10 wherein the non-solvent is ethyl alcohol.

12. Process according to any one of the preceding claims wherein the ferric compound is added to a mixture of the α-hydroxy-carboxylic acid and the hexitol component.

13. Process according to Claim 12 wherein the ferric compound is added in portions and the solution is neutralised after the addition of each portion.

14. Process according to any one of the preceding claims wherein the mixing of the ferric compound, α-hydroxycarboxylic acid and hexitol component takes place in the presence of a water-soluble dispersion stabiliser for the complex.

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solving 25 cc. hydroxypropyl-sorbitol (Atlas Powder Company No. G-2401) and 75.0 grams of dextrin in 225 cc. of distilled water. On solution of these constituents at 60° C., 10.5 grams of citric acid were added. To the solution formed 22.5 cc. of a solution of 45.0 grams of sodium hydroxide in 225 cc. of distilled water were added. Then 84.0 grams of ferric chloride hexahydrate dissolved in 115 cc. of distilled water were added in 8 portions. After each portion of ferric compound, 23 cc. of the above sodium hydroxide solution were added. When the addition of ferric compound and sodium hydroxide was finished the *p*H of the reaction mixture was adjusted to 8.15. The mixture was kept at the temperature of 60° C. for another 30 minutes, after which it was cooled to room temperature, and diluted to 675 cc. with distilled water. Then 2025 cc. of 83% ethanol were added. After the sedimentation of the resulting precipitate the mother liquor was separated. The precipitate obtained was treated with 150 cc. of ethanol of the same concentration as the mother liquor and then dried on a Nutsche. It was then dissolved at 60° C. with stirring in 450 cc. of distilled water containing 3.0 grams of crystallised citric acid. The *p*H of the solution was adjusted to 8.2 and heating was continued for some minutes. The solution was then cooled to 30° C., filtered and diluted to 675 cc. with distilled water and once more precipitated with 2025 cc. of 83% alcohol. After half an hour the mother liquor was separated and the precipitate washed twice with 150 cc. of alcohol of the same concentration as the mother liquor and 3 times with concentrated alcohol. The washed precipitate was dried 15 hours *in vacuo* at a temperature of 45—50° C. Yield: 97.4 grams of a preparation with a total iron content of 15.3%.

49.0 grams of the dried preparation were added in portions to a solution of 12.5 ml. hydroxypropyl-sorbitol in 105 cc. of distilled water at 60° C. while stirring. After 20 minutes the *p*H of the solution was adjusted to 8.2 with sodium hydroxide. After 1 hour the solution obtained was cooled to room temperature and diluted with distilled water to a volume of 150 cc. After filtering through filter paper and a sterile filter the solution was dispensed in ampoules, which were sterilised in an autoclave at 120° C. for 20 minutes. The prepared injection solution had a total iron content of 54.0 mg/cc. and a *p*H of 7.1. It gave an absorption of 84% from rabbit muscle after 7 days.

WHAT WE CLAIM IS:—

1. Process for the production of a dry-iron-containing composition which can be worked up into a preparation suitable for intramuscular injection in human and veterinary medicine which comprises mixing together in aqueous solution at least one soluble ferric salt of a physiologically innocuous acid, an α-hydroxy carboxylic acid and a hexitol component which is a hexitol, a uronic acid derivable from a hexitol or a hydroxy-lowerakyl hexitol, or two or more of these, the α-hydroxy carboxylic acid and the hexitol component being physiologically innocuous and being capable individually of forming complexes with ferric iron at *p*H 5—10; precipitating the iron-containing complex thus formed; and purifying and drying the precipitate.

2. Process according to Claim 1 wherein the α-hydroxycarboxylic acid is one or more of citric, gluconic, tartaric and malic acids.

3. Process according to Claim 1 or 2 wherein the hexitol component is mannitol, dulcitol, sorbitol, iditol, or hydroxypropyl sorbitol, or two or more of these.

4. Process according to Claim 1 or 2 wherein the hexitol component is a uronic acid or hydroxyloweralkyl hexitol derivable from dulcitol, sorbitol, mannitol or iditol, or two or more of these.

5. Process according to Claim 1 or 2 wherein the α-hydroxycarboxylic acid is citric acid and the hexitol component is sorbitol.

6. Process according to any one of the preceding claims wherein the soluble ferric compound is ferric chloride.

7. Process according to any one of Claims 1 to 5 wherein the soluble ferric compound is ferric nitrate, sulphate or acetate.

8. Process according to any one of Claims 1 to 5 wherein the soluble ferric compound is ferric ammonium sulphate or other double salt.

9. Process according to any one of the preceding claims wherein the *p*H of the aqueous solution is from 5 to 10 and the complex is precipitated by the addition of a non-solvent for the complex.

10. Process according to Claim 9 wherein the *p*H is from 8.0 to 8.4.

11. Process according to Claim 9 or 10 wherein the non-solvent is ethyl alcohol.

12. Process according to any one of the preceding claims wherein the ferric compound is added to a mixture of the α-hydroxy-carboxylic acid and the hexitol component.

13. Process according to Claim 12 wherein the ferric compound is added in portions and the solution is neutralised after the addition of each portion.

14. Process according to any one of the preceding claims wherein the mixing of the ferric compound, α-hydroxycarboxylic acid and hexitol component takes place in the presence of a water-soluble dispersion stabiliser for the complex.

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15. Process according to Claim 14 wherein the dispersion stabiliser is a water-soluble carbohydrate.

16. Process according to Claim 15 wherein the dispersion stabiliser is dextrin, glucose, saccharose or a low molecular weight dextran fraction.

17. Process according to Claim 16 wherein the dispersion stabiliser is a dextrin containing per gram of dextrin a number of reducing groups corresponding to 40—200 milligrams of glucose.

18. Process according to any one of Claims 14 to 17 wherein there is prepared a mixture containing by weight 1 to 10% of the α-hydroxycarboxylic acid, 2 to 20% of the hexitol component and 5 to 50% of the dispersion stabiliser, and the ferric compound is added to the mixture in an amount equal to 1.0 to 35 moles per mole of the hexitol component.

19. Process according to any one of the preceding claims wherein the ferric compound, hexitol component and α-hydroxy carboxylic acid are mixed at a temperature of 18—100° C.

20. Process according to Claim 19 wherein the temperature is 50—70° C.

21. Process according to any one of the preceding claims wherein the ferric compound is used in an amount sufficient to provide a final composition containing 5 to 30% by weight of iron.

22. Process according to Claim 21 wherein the ferric compound is used in an amount sufficient to provide a final composition containing 12 to 16% by weight of iron.

23. Process according to any one of preceding claims which is carried out under conditions such that the final compostion is in the form of particles at least 50% by weight of which have a sedimentation constant (determined as set out herein) less than 17×10^{-13} sec.

24. Process according to Claim 23 which is carried out under conditions such that the final composition is in the form of particles, at least 90% of which have a sedimentation constant less than 17×10^{-13} sec.

25. Process according to Claim 23 or 24 wherein the particles have a sedimentation constant less than 14×10^{-13} sec.

26. Process according to Claim 1 substantially as hereinbefore described.

27. Process according to Claim 1 substantially as described in any one of the foregoing examples.

28. A dry iron-containing composition produced by the process of any of the preceding claims.

29. A modification of the process claimed in any one of Claims 1 to 27 wherein the iron-containing complex formed by mixing the ferric salt, the α-hydroxycarboxylic acid and the hexitol component is worked up *in situ* into a preparation suitable for intramuscular injection in human and veterinary medicine.

30. An iron-containing preparation produced by a process as claimed in Claim 29.

31. An iron-containing preparation suitable for intramuscular injection in human and veterinary medicine which comprises an aqueous solution of a dry-iron-containing composition as claimed in Claim 28.

32. An iron-containing preparation according to Claim 31 having a *p*H from 5 to 10.

33. An iron-containing preparation according to Claim 31 having a *p*H from 7.3 to 7.7.

34. An iron-containing preparation according to any one of Claims 31 to 33 containing 5 to 60 milligrams of iron per millilitre.

35. An iron-containing preparation according to Claim 34 containing per millilitre the equivalent of 10 to 300 milligrams of the hexitol component, 10 to 70 milligrams of the α-hydroxy carboxylic acid and 150 to 350 milligrams of the water-soluble dispersion stabiliser.

36. An iron-containing preparation according to any one of Claims 31 to 35 which contains in addition a further quantity of the hexitol component in amount less than 165 milligrams per millilitre of solution.

37. An iron-containing preparation according to Claim 31 substantially as described in any one of the foregoing examples.

38. A dry iron-containing composition which can be worked up into a preparation suitable for intramuscular injection in human and veterinary medicine which comprises as the active constituent a complex of trivalent iron, an α-hydroxycarboxylic acid and a hexitol component which is a uronic acid derivable from a hexitol or a hydroxy lower alkyl hexitol or two or more of these, the α-hydroxycarboxylic acid and the hexitol component being physiologically innocuous and being capable individually of forming complexes with ferric iron at *p*H 5—10.

39. A composition according to Claim 38 wherein the α-hydroxycarboxylic acid is one or more of citric, gluconic, tartaric and malic acids.

40. A composition according to Claim 38 or 39 wherein the hexitol component is a uronic acid or hydroxy lower alkyl hexitol derived from dulcitol, sorbitol, mannitol or iditol, or two or more of these.

41. A dry iron-containing composition which can be worked up into a preparation suitable for intramuscular injection in human and veterinary medicine which comprises as the active constituent a complex of trivalent iron, an α-hydroxycarboxylic acid which

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is one or more of citric, tartaric and malic acids and a hexitol component which is a hexitol, a uronic acid derivable from a hexitol or a hydroxy lower alkyl hexitol, or two or more of these, the hexitol component being physiologically innocuous and being capable of forming a complex with ferric iron at *p*H 5—10.

42. A composition according to Claim 41 wherein the hexitol component is mannitol, dulcitol, sorbitol, iditol or hydroxypropyl sorbitol, or two or more of these.

43. A composition according to any one of Claims 38 to 42 which contains a water-soluble dispersion stabiliser.

44. A composition according to any one of Claims 38 to 43 which contains 12 to 16% by weight of iron.

45. A composition according to any one of Claims 38 to 44 which is in the form of particles at least 90% by weight of which have a sedimentation constant (determined as set out herein) of less than 17×10^{-13}.

46. An iron-containing preparation suitable for intramuscular injection in human and veterinary medicine which comprises an aqueous solution of a composition as claimed in any one of Claims 38 to 45.

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