

[54] **FERROMAGNETIC COMPOSITIONS OF MATTER**

[75] Inventors: **Ephraim H. Frei; Shmuel Yerushalmi; Yusuf Benmair**, all of Rehovot, Israel

[73] Assignee: **Yeda Research & Development Co. Ltd.**, Rehovoth, Israel

[22] Filed: **May 8, 1973**

[21] Appl. No.: **358,404**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 94,380, Dec. 2, 1970, abandoned.

[30] **Foreign Application Priority Data**

Dec. 3, 1969 Great Britain..... 58966/69

[52] U.S. Cl..... **252/62.56, 128/2 A, 252/62.62, 252/62.64**

[51] Int. Cl..... **C04b 35/26**

[58] **Field of Search** 252/62.64, 62.51; 128/2 A, 128/2 S; 324/41

[56] **References Cited**
UNITED STATES PATENTS

3,741,198 6/1973 Burton..... 128/2 A

Primary Examiner—Oscar R. Vertiz

Assistant Examiner—Ethel R. Cross

Attorney, Agent, or Firm—Ostrolenk, Faber, Gerb & Soffen

[57] **ABSTRACT**

A process for the measurement of peristalsis. A ferromagnetic composition for the measurement of peristalsis, for diagnostic and therapeutic purposes.

6 Claims, No Drawings

FERROMAGNETIC COMPOSITIONS OF MATTER RELATED APPLICATIONS

This is a continuation-in-part of Application Ser. No. 94380 filed Dec. 2, 1970, now abandoned.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a novel method for the measurement of peristalsis, to novel compositions of matter for diagnostic and for therapeutic purposes.

DESCRIPTION OF THE PRIOR ART

Various methods have been proposed for the measurement of peristalsis, and especially of the peristaltic movement of the stomach and intestines in humans, but these have not been developed into widely used and generally accepted clinical methods. Swallowed magnets have been used in order to show peristalsis, but the movement of the magnet, once it has been swallowed, can be followed only with difficulty and provides only scanty information. Magnets have been implanted in the stomach walls of laboratory animals, but this method is not applicable to humans. The passage of barium meal through the intestinal tract can be studied by means of X-rays, but this involves high exposures to radiation, which considerably limits the applicability of this method. Various ferromagnetic compositions have been proposed for this purpose. It is also known that the rheological properties of barium sulfate can be improved by the addition of sorbitol and citric acid, the effect being due, according to its discoverers, to an influence of these additives on the sulfate ions, resulting in a better wetting of the particles. Ferrites alone have the drawback of a lesser degree of X-ray absorption as compared with barium sulfate. Barium sulfate by itself gives good X-ray pictures, but it cannot be manipulated from the outside of the body once it has been ingested.

SUMMARY OF THE INVENTION

The present invention relates to a number of improvements in the use of ferromagnetic materials for diagnostic and for therapeutical purposes, to novel compositions of matter for these uses and to a novel device for the determination of the movement of ingested ferromagnetic materials through the gastrointestinal tract.

The compositions according to the present invention are characterized by the possibility to manipulate them from the outside of the body by the application of a suitable magnetic field; they have good covering properties and they can also be viewed by X-rays. The process according to the present invention for the measurement of peristalsis and for the determination of the velocity of movement of ingested material through various parts of the gastrointestinal tract and their retention therein is of diagnostic value and can also be used as an indicator for the functioning of various organs of the body. The movement of such ferromagnetic materials through the gastrointestinal tract can be monitored by various conventional means, such as X-rays, magnetometers and the like.

DESCRIPTION OF PREFERRED EMBODIMENTS

According to the present invention there is provided an improved ferromagnetic contrast material for diagnostic and therapeutical purposes, which comprises in combination small particles of a suitable ferrite sorbitol

and citric acid. The ferrites so utilized are ferromagnetic ceramic oxides containing two magnetic lattices which are opposed to one another but which do not cancel each other out. Ferrites which may be employed include magnesium ferrite, barium ferrite, manganese ferrite, manganese-zinc ferrite, magnesium-zinc ferrite, and nickel ferrite. These ferrites generally possess a high enough magnetization, e.g., about 30 e.m.u. per gram at body temperature to permit control by external magnetic fields. If desired, a certain quantity of barium sulfate can be added, and this enhances the opacity towards X-rays. It is of course to be understood that before ingestion a quantity of water is added to these ingredients, the mixture is stirred and thus a slurry or suspension of suitable consistency is obtained which can be swallowed by the person to be diagnosed or treated. Any suitable ferrite may be used which has suitable magnetic properties, and which is physiologically acceptable, so that it can be ingested and causes no problems during the period of time when it passes through the digestive tract of the patient.

Advantageously there is used a ferrite of the type defined above, which contains an excess of magnesium oxide over the stoichiometrical ratio. An excess of about 10 percent over the stoichiometrical ratio enhances the saturation magnetisation of the ferrite. It is clear that also other suitable biologically acceptable ferrites of adequate saturation magnetisation can be used, but especially good results were obtained with magnesium ferrite with an excess of about 10 percent magnesium oxide which has both good magnetic and biological properties. Also the other ferrites defined above are satisfactory in these respects. The ferrites are prepared by conventional means, as known in the art, and the obtained material is finely ground till a particle size of from about 1 to 50 microns is obtained. When magnesium ferrite is rapidly quenched immediately after sintering, there is obtained a higher saturation magnetisation than when the material is cooled gradually.

The novel compositions comprising sorbitol and citric acid have a higher fluidity, and for a given fluidity there can be incorporated greater quantities of ferrite as compared with compositions without these two ingredients. It is clear that a lesser viscosity facilitates the swallowing of the preparation, and that a larger content of ferromagnetic material improves both the opacity towards X-rays and also facilitates the movement of the ingested material by the application of a magnetic field from the outside of the body.

The ferrites defined above are substantially inert in the environment of the gastrointestinal tract, and they can be manipulated from the outside of the body by magnetic fields. They are good contrast materials as regards coating properties and as regards absorption of X-rays. The absorption of X-rays is inferior to that of barium sulfate, and thus it is advantageous for certain purposes to add a certain percentage of barium sulfate, which will generally be from zero to about 30 percent by weight of the entire composition of matter.

In the following there are given by way of example compositions of matter for the above purposes. The magnesium ferrite containing an excess of about 10 percent of magnesium oxide was obtained by sintering of the necessary components. It is used in the form of particles of from 1 to 50 microns. The other ferrites were prepared in a similar manner. For therapeutic

purposes an active ingredient can be added, and when ingested, the material is monitored as it passes through the gastrointestinal tract, and it can be held in place at a desired location by the application of an external magnetic field.

In the following examples the parts are parts by weight.

EXAMPLE 1

Magnesium ferrite (MgFe_2O_4 , 10% excess of MgO)	200 parts
Sorbitol	7 parts
Citric acid	0.7 parts
Water	30 parts

Before use, there were mixed 100 parts ferrite, the sorbitol, the citric acid and the water. After obtaining a homogenous suspension, the remaining 100 parts of ferrite were added and mixing was continued until a homogenous mixture was obtained. The resulting suspension had a consistency similar to that of maple syrup. This could be ingested without difficulty and gave good results when viewed by X-rays. It could be moved in the stomach by the application of a magnetic field from the outside of the body.

EXAMPLE 2

Magnesium ferrite (as in Example 1)	120 parts
Sorbitol	8 parts
Citric acid	0.7 parts
Barium sulfate (1 to 20 microns)	70 parts
Water	30 parts

All ingredients, except for 70 parts of the ferrite, were mixed and stirring was continued till a homogenous slurry was obtained. The rest of the ferrite was added and stirring was continued until a homogenous mixture was obtained. The consistency of this was similar to the composition of Example 1.

The opacity of this composition to X-rays is greater than that of the composition of Example 1. The coating properties of the composition are satisfactory, and it can be manipulated in the stomach and in the other parts of the gastrointestinal tract by an external magnetic field of adequate field strength.

EXAMPLE 3

Barium ferrite (BaFe_2O_4 , 10% excess of BaO)	200 parts
Sorbitol	10 parts
Citric acid	1 part
Water	35 parts

Before use half the ferrite, the sorbitol, the citric acid and the water were mixed until a homogenous suspension was reached. The remainder of the ferrite was added and mixing was continued till a homogenous mixture was obtained. The consistency and use was the same as in Example 1.

EXAMPLE 4

A mixture was prepared, comprising 200 parts of magnesium-zinc ferrite instead of the barium ferrite of Example 3. The preparation and the other ingredients were the same. The properties of the homogenous mixture obtained were practically identical with those of Example 3.

EXAMPLE 5

A mixture was prepared from 200 parts nickel ferrite, 4 parts sorbitol, 0.5 parts citric acid and 30 parts water. The preparation was the same as in Example 1. The homogenous suspension obtained had similar properties to those of the suspension obtained in Example 1.

EXAMPLE 6

A mixture was prepared comprising 100 parts magnesium ferrite and 100 parts magnesium-zinc ferrite, 10 parts sorbitol, 1 part citric acid and 35 parts water. Half of the ferrite mixture was admixed with the other ingredients, homogenized and the remainder of the ferrite was added and homogenized. The properties and uses are like those of the suspension of Example 1.

EXAMPLE 7

A mixture was prepared wherein instead of 200 parts barium ferrite of Example 3 there were used 150 parts ferrite and 50 parts barium sulfate. The other ingredients and the manner of preparation were as in Example 3. The properties of the suspension were like those of Example 2.

EXAMPLE 8

A mixture was prepared consisting of 100 parts of magnesium ferrite, 50 parts manganese ferrite and 50 parts barium sulfate, together with 8 parts sorbitol and 0.9 parts citric acid and 30 parts water. The preparation was as in Example 2 and the consistency and properties were as those of the suspension of Example 2.

Various compositions were prepared, and it has been found that the quantity of the ingredients can be varied within certain limits while still resulting in satisfactory compositions. The quantity of sorbitol can vary from about 3 to 6 percent of the entire composition (by weight) and that of citric acid from about 0.3 percent to 0.6 percent.

For diagnostic purposes a certain quantity of a composition of the type exemplified in any of Examples 1 to 8 is ingested by the person to be diagnosed, and this may be given together with some pudding or the like. Quantities of from about 10 to 200 grams of the composition are ingested, depending on the measurement intended. The passage of the composition through the gastrointestinal tract, and the arrival of the said ferromagnetic composition at a predetermined location in the gastrointestinal tract can be monitored. It is possible to ingest a certain quantity of this material and to determine the retention time in the stomach. Furthermore, the novel ferromagnetic compositions according to the present invention are good contrast media for X-ray examination of various parts of the gastrointestinal tract. They can be moved by the application of an external magnetic field, and thus facilitates the determination of the exact location of malignant growths and the like.

The movement of the ferromagnetic compositions according to the present invention through the gastrointestinal tract can be monitored, as already mentioned, by the use of X-rays and also by the use of sensitive magnetometers.

We claim:

1. A ferromagnetic composition of matter for diagnostic purposes, consisting essentially of a magnetic physiologically acceptable ferrite, from the group con-

5

sisting of magnesium ferrite, barium ferrite, manganese ferrite, manganese-zinc ferrite, magnesium-zinc ferrite, and nickel ferrite, and having incorporated therewith, at least one member from the group consisting of sorbitol and citric acid.

2. A ferromagnetic diagnostic composition as claimed in claim 1 wherein the sorbitol comprises 3 to 6 percent by weight and the citric acid comprises 0.3 to 0.6 percent by weight of the composition.

3. A ferromagnetic composition of matter according to claim 1 wherein the magnetic ferrite is selected from the group consisting of magnesium ferrite, barium ferrite, manganese ferrite, manganese-zinc ferrite, magnesium-zinc ferrite, nickel ferrite and mixtures of these.

6

4. A ferromagnetic diagnostic composition of matter according to claim 1 containing up to 30 percent by weight of the composition of small particle size barium sulfate.

5. A ferromagnetic composition according to claim 1, consisting essentially of 200 parts of magnesium ferrite, 3 to 6 percent sorbitol, 0.3 to 0.6 percent citric acid and about 30 parts water.

6. A ferromagnetic composition according to claim 5, consisting essentially of 120 parts magnesium ferrite and 70 parts barium sulfate, 3 to 6 percent sorbitol, 0.3 to 0.6 percent citric acid and about 30 parts water.

* * * * *

15

20

25

30

35

40

45

50

55

60

65