

Description**BACKGROUND OF THE INVENTION**5 **Field Of The Invention**

This invention relates to the art of arc welding and more particularly, to a flux-cored wire for gas shielded arc welding which exhibits a good pore formation resistance in gas shielded arc welding of carbon steels and low alloy steels, particularly corroded or paint coated steels.

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Description Of The Prior Art

In the fields of shipbuilding and bridge construction, titania flux-cored wires have been frequently employed in gas shielded arc welding and particularly, in carbon dioxide arc welding. This is because the
15 titania-based flux-cored wire makes all position welding at a high efficiency and ensures a good appearance and shape of beads and good welding operability. In order to prevent steel materials from corrosion in the above fields of consumption, however, it is usual to apply, prior to welding, primary rust preventive paints (hereinafter referred to simply as primer) such as wash primers, inorganic zinc primers and the like. This presents the problem that at the time of welding and particularly, fillet welding, pores such as pits, gas
20 grooves and the like are often produced with a lowering of quality and an additional number of steps for re-adjustment.

For solving the above problem, the primer at or around welding portions is preliminarily removed by polishing with a grinder or a paper machine. The polished portion is liable to produce corrosion, thus placing limitation on a storage period not only outdoors, but also indoors.

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On the other hand, there has been developed a high hydrogen rate wire having an amount of weld metal-diffusible hydrogen of from 20 to 30 ml/100 grams as a flux-cored wire having a pore resistance against primer-coated steel sheets. In view of the possibility in occurrence of low temperature crack, its application is limited to soft steels and structures wherein a degree of restriction on thin sheets is small.

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SUMMARY OF THE INVENTION

It is accordingly an object of the invention to provide a flux-cored wire for gas shielded arc welding which is applicable to various steel materials without limitation.

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It is another object of the invention to provide a flux-cored wire for gas shielded arc welding which whereby pores such as pits and gas grooves are not produced in welding of steel materials on or in which primers have been applied or corrosion has taken place, thereby ensuring a good bead.

It is a further object of the invention to provide a flux-cored wire which makes use of the merits involved in known titania-based flux-cored wires and which solves the problems involved in primer-coated steel sheets.

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The above objects can be achieved, according to the invention, by a flux-cored wire for gas shielded arc welding which comprises a steel sheath and a flux composition filled in the steel sheath at a flux rate of 8 to 25 wt%, the flux composition comprising, based on the weight of the total flux, 10 to 30% of TiO_2 , 0.1 to 0.6% of Na_2O provided that a ratio of TiO_2 and Na_2O is in the range of 20 to 100: 1, 0.01 to 2.0% of a metal fluoride calculated as F, and 0.005 to 0.4% of moisture.

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Optionally, Bi_2O_3 may be further contained in the composition provided that the ratio of Na_2O and Bi_2O_3 is in the range of 1 to 10: 1.

BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 is a graphical representation of the $\text{TiO}_2/\text{Na}_2\text{O}$ ratio in relation to the bead form, the pit formation resistance and the gas groove formation resistance; and
Fig. 2 is a schematic view of a shape of welding joint used in Example.

PREFERRED EMBODIMENTS OF THE INVENTION

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The reasons why the types and contents of flux components are determined in the present invention are described along with their effects.

TiO₂: 10 to 30%

TiO₂ is a flux component as a base. If the content is less than 10%, the amount of slug becomes insufficient, so that the slug does not cover the entire surface of the resultant bead, with a failure in the bead appearance. On the other hand, over 30%, the slug-covering property becomes good. However, since TiO₂ has a high solidifying temperature and the slug is quickly solidified, gas components such as hydrogen and water vapor produced from the primer or rust are prevented from escaping to outside, with a tendency that gas groove defects are formed in the bead surface.

Accordingly, the amount of TiO₂ is in the range of from 10 to 30%, preferably from 15 to 25%. TiO₂ sources may include rutile, reduced ilmenite, leucoxene, white titanium, titanium slug and the like.

Na₂O: 0.1 to 0.6%

Na₂O can lower the slug viscosity and permits gas components such as hydrogen and water vapor and metallic vapors such as Zn, which will cause formation of pores in the molten metal, to be readily floated, thus facilitating them to be escaped to outside. In addition, when used in small amounts, this component has the effect of improving the arc stability. However, if the content of Na₂O is less than 0.1%, the above effect is not expected. On the other hand, over 0.6%, a melt drop becomes too large in size, with the result that its transfer becomes irregular, leading to an increase of spatter.

Accordingly, the content of Na₂O is in the range of from 0.1 to 0.6%, preferably from 0.2 to 0.4%. The sources for Na₂O include feldspar, water glass, anhydrous sodium silicate, soda glass and the like.

The above flux components should be properly controlled in such a way that the ratio, TiO₂/Na₂O, is within the following range.

TiO₂/Na₂O ratio: 20 to 100: 1

Na₂O has to be properly added depending on the amount of TiO₂. This is because TiO₂ and Na₂O have reverse actions on the viscosity properties. The former serves to increase the viscosity and the latter decreases the viscosity. When the amount of Na₂O is increased, the slug becomes dense, tending to degrade the slug releasability.

More particularly, as shown in Fig. 1, when the ratio of TiO₂ and Na₂O is less than 20: 1, the slug viscosity lowers excessively, under which a bead shape control of the slug cannot be expected. Especially, in horizontal fillet welding, the bead is shaped in a convex form and the slug releasability is worsened. Thus, such a ratio is unfavorable.

When the ratio of TiO₂ and Na₂O exceeds 100: 1, the slug viscosity becomes excessive, pores such as pits, gas grooves and the like are unfavorably liable to produce with paint-coated or corroded steel sheets.

When the ratio of TiO₂/Na₂O is in the range of 20 to 100: 1, good bead shape, pit formation resistance and gas groove formation resistance (i.e. pore formation resistance) are attained. Also, good slug releasability is obtained.

Accordingly, the ratio (by weight) of TiO₂/Na₂O is controlled to be in the range of 20 to 100: 1, preferably 40 to 80: 1.

Metal Fluoride (calculated as F): 0.01 to 2.0%

Metal fluorides such as CaF₂, NaF, AlF₃, BaF₂, Na₃AlF₆, Na₂SiF₆, K₂SiF₆, K₂ZrF₆, LiF₂, MgF₂, SrF₂ and the like act to control the convergence of arc and the viscosity of slug in order to dissipate gases which cause pores to be produced. The fluorides also act to reduce an amount of diffusible hydrogen which causes the low temperature crack of weld metals. Accordingly, the amount of the metal fluoride is in the range of from 0.01 to 2.0% calculated as F. At less than 0.01%, the above effect is not expected. On the other hand, over 2.0%, although the amount of diffusible hydrogen is reduced, an arc becomes too intense with respect to welding operability, leading to an unfavorable tendency toward an increase of spatter and undercut defects. Accordingly, the content, as F, of the metal fluoride is in the range of from 0.01 to 2.0%, preferably from 0.1 to 1.0%.

Moisture: 0.005 to 0.4%

With regard to moisture, there may be the case where moisture is intentionally added or the case where moisture is reduced to an extent as small as possible. In the practice of the invention, moisture is purposely

added as in the former case. More particularly, it is general that when welding current and voltage are varied, arc stability is deteriorated. If moisture is purposely added, an allowance in the arc stability becomes wide for the variation of the welding current and voltage. However, when the moisture content is less than 0.005%, the effect is not expected. Over 0.4%, an arc becomes too intense or spatter unfavorably increases.

Accordingly, the moisture content is in the range of from 0.005 to 0.4%, preferably from 0.005 to 0.1%. It will be noted that the measurement of the moisture content is made according to Karl Fischer's method using a heating temperature of 750 °C and an atmospheric gas of Ar.

In the present invention, Bi_2O_3 may be appropriately added, if necessary. The amount of Bi_2O_3 is preferably in the range of from 0.01 to 0.6%.

$\text{Na}_2\text{O}/\text{Bi}_2\text{O}_3$ Ratio: 1 to 10: 1

In general, Bi_2O_3 is used to improve the releasability of slug. In an ordinary case, mere addition may be sufficient, but with corroded steel sheet or welding at narrowed portions, little effect can be expected. It has been found that when Bi_2O_3 is added, it is necessary to make a balance in amount of Na_2O , by which good slug releasability can be obtained at the portions mentioned above. More particularly, the ratio of $\text{Na}_2\text{O}/\text{Bi}_2\text{O}_3$ is determined to be in the range of 1 to 10:1, preferably 1 to 5:1. When the ratio is less than 1:1 or larger than 10:1, the slug releasability at narrowed portions becomes poor.

Flux Rate: 8 to 25%

When the flux rate is less than 8%, the arc becomes unstable with an unfavorably increasing amount of spatter. Over 25%, the amount of slug unfavorably increases with an increase in fluidity of the slug along with the bead being irregular. The flux rate is in the range of from 8 to 25%.

The flux composition comprises, aside from the above components, the balance of a slug-forming agent such as K_2O , SiO_2 , ZrO_2 , MgO , Al_2O_3 , MnO_2 , MnO , FeO , Fe_2O_3 , Fe_3O_4 , LiFeO_2 , Li_2SiO_3 , Li_2MnO_3 , B_2O_3 and the like and a metallic powder such as Mn, Si, Al, Ni, Cr, Mo, Cu, B, Li, Fe and the like as in the case of titania-based flux-cored wires. In the practice of the invention, any limitation is not placed on the sectional shape and diameter of the flux-cored wire according to the invention, the composition of a steel sheath (such as of carbon steels, low alloy steels and the like), shielding gases, types of steels to be applied and the like.

The present invention is described by way of examples.

Example

A metallic sheath constituting a wire was made of a low carbon steel (C: 0.05%, Si: 0.01%, Mn: 0.42%, P: 0.005%, S: 0.003%), in which fluxes having compositions indicated in Table 1 were filled at a flux rate of 15%, thereby making flux-cored wires.

The thus made wires were used for performing a gas-shielded fillet arc welding test under the following welding conditions.

(Welding Conditions)

Diameter of the wire: 1.2 mm ϕ

Welding current-voltage: 300A-32V

Welding rate: 70 cpm.

Tested steel sheet: 12 mm thick x 100 mm wide x 1000 mm long paint-coated steel sheet (amount of paint coating: 30 - 40 μ)

Joint shape: see Fig. 2.

Shielding gas: 100% CO_2 , 25 liters/minute

The results of the welding test are shown in Table 2.

In Table 2, Wire Nos. A are for comparison and Wire Nos. B are for examples of the invention.

The results of Table 2 reveal that Comparative Example A-1 is a case where TiO_2 is insufficient with an excess of Na_2O . In this case, the covering properties of the slug are poor. Since an arc becomes too intense, the beads are not uniformly formed with an increase in amount of spatter.

In Comparative Example A-2, TiO_2 is used in excess and an amount of fluorine is also in excess. The resistance to pore formation is very poor with an increasing amount of spatter, and undercut defects are

liable to occur.

Comparative Example A-3 is a case where Na_2O and moisture are in shortage. The arc is slightly unstable with spatter being produced in large amounts. The bead is of a convex form.

Comparative Example A-4 is a case where Na_2O and moisture are both in excess. The arc is converged
5 and is too intense, so that the arc is unstable with a very great amount of spatter.

Comparative Example A-5 is a case where the fluorine is insufficient and moisture is in excess. Accordingly, an amount of diffusable hydrogen increases and the arc is greatly influenced by the excess moisture. The arc is too intense with an increasing amount of spatter.

Comparative Examples A-6 and A-7 are cases where the $\text{TiO}_2/\text{Na}_2\text{O}$ ratios are outside the scope of the
10 invention. Although the arc stability and the amount of spatter are good, the pore formation resistance is very poor.

Comparative Examples A-8 and A-9 are cases where the $\text{TiO}_2/\text{Na}_2\text{O}$ ratio is outside the scope of the invention although the $\text{Na}_2\text{O}/\text{Bi}_2\text{O}_3$ ratio is within the scope of the invention. Thus, the slug releasability is not improved.

15 In contrast, Examples B-1 to B-10 of the invention are good with respect to the arc stability, resistance to pore formation, spatter and bead. The slug releasability is also good. Especially, better slug releasability is obtained in Examples B-8 to B-9 of the invention wherein the $\text{Na}_2\text{O}/\text{Bi}_2\text{O}_3$ ratio is within a range of 1 to 10: 1.

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Table 1 Flux Composition (wt% based on total flux)

Wire No.	TiO ₂	Na ₂ O	F (amount calculated)	Moisture	K ₂ O	SiO ₂	ZrO ₂	MgO	Al ₂ O ₃
A-1	9.5	0.70	0.05	0.10	1.0	7.0	4.0	-	-
A-2	33	0.50	2.1	0.05	-	10.0	-	2.0	7.0
A-3	15	0.09	1.0	0.004	0.5	5.0	1.0	1.5	3.0
A-4	27	0.65	1.0	0.55	-	-	10.0	5.0	1.0
A-5	12	0.50	0.009	0.42	0.7	2.5	-	-	4.0
A-6	11	0.55	0.08	0.15	-	15	-	1	-
A-7	22	0.20	1.5	0.015	1.0	10	20	-	1
A-8	22	0.20	0.5	0.015	-	-	12	2	2
A-9	9.5	0.70	0.05	0.10	0.8	11.0	5.0	7.0	4.5
B-1	11	0.25	0.02	0.008	0.15	5.5	13.5	3.0	1.0
B-2	29	0.50	1.8	0.19	0.10	10.0	3.0	-	-
B-3	15	0.40	1.0	0.01	-	15.0	15.0	2.0	4.0
B-4	15	0.15	0.05	0.10	0.50	-	7.5	10.0	3.0
B-5	11	0.50	0.9	0.09	1.0	7.0	-	7.0	4.5
B-6	26	0.40	0.01	0.006	0.2	6.0	5.5	3.0	1.0
B-7	22	0.45	0.04	0.08	-	18.0	1.0	1.0	10.0
B-8	26	0.35	0.25	0.38	0.5	4.0	12.0	4.0	2.0
B-9	13	0.20	0.30	0.05	0.4	5.5	21	3.5	1.0
B-10	27	0.58	0.60	0.009	1.1	9.5	11.0	7.0	6.5

Table 1 Cont'd

	Bi ₂ O ₃	Mn	Si	FeO	Iron Powder	TiO ₂ /Na ₂ O Ratio	Na ₂ O/Bi ₂ O ₃ Ratio
5							
10	-	18	5	-	balance	13.5	-
	-	16	4	-	do.	66	-
15	-	5	4	0.3	do.	166	-
	-	6	3	-	do.	41	-
	-	6	2	-	do.	24	-
20	-	8	2	0.1	do.	19.6	-
	-	9	3	-	do.	110	-
	-	9	2	-	do.	110	-
25	0.04	10	5	-	do.	13.5	-
	0.14	10	4	-	do.	44	-
30	-	9	3	0.5	do.	58	-
	-	10	2	-	do.	37	-
	-	6	3	-	do.	100	-
35	-	4	5	0.1	do.	22	-
	-	18	4	-	do.	65	-
	0.56	9	4	-	do.	48	0.8
40	0.04	7	2	0.2	do.	74	9.5
	0.04	7	3	-	do.	65	5.0
45	0.05	6	2	-	do.	46	11.6

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Table 2

Wire No.	Results Of Evaluation Of Welding					
	resistance to pore formation	arc Stabil-ity	amount of spatters	shape of bead	uniform-ity of bead	slug releas-ability
Comparative Examples:						
A-1	△	△	X	△	X	X
A-2	X	△	X	△	△	△
A-3	X	△	X	△	△	X
A-4	X	X	X	△	△	X
A-5	△	△	X	△	△	X
A-6	X	○	○	△	○	○
A-7	X	○	○	△	○	○
A-8	X	△	△	△	△	△
A-9	△	X	X	△	△	△
Inventive Examples:						
B-1	◎	○	○	○	◎	○
B-2	◎	◎	◎	○	○	○
B-3	◎	○	○	○	◎	○
B-4	◎	○	○	○	◎	○
B-5	◎	○	○	○	◎	○
B-6	◎	◎	◎	◎	○	○
B-7	◎	◎	◎	○	○	○
B-8	◎	◎	◎	◎	○	◎
B-9	◎	○	○	○	◎	◎
B-10	◎	◎	◎	◎	○	○
Note: Standards for evaluation of the results of the welding:						
◎ : very good ○ : good △ : slightly poor x: poor						

As will be apparent from the foregoing description, the flux-cored wires of the present invention are applicable to various types of steels including paint-coated steel sheets and corroded steel sheets. Even for fillet welding, pores such as pits and gas grooves are not produced without involving any undercut defect and with uniform, smooth beads being obtained. Since the slug releasability is very excellent, the number of welding steps can be reduced in welding of narrow fillet joints of red rust steel sheets.



Claims

1. A flux-cored wire for gas shielded arc welding which comprises a steel sheath and a flux composition filled in the steel sheath at a flux rate of 8 to 25 wt%, the flux composition comprising, based on the weight of the total flux, 10 to 30% of TiO_2 , 0.1 to 0.6% of Na_2O provided that a ratio of TiO_2 and Na_2O is in the range of 20 to 100:1, 0.01 to 2.0% of a metal fluoride calculated as F, and 0.005 to 0.4% of moisture.
2. A flux-cored wire according to Claim 1, wherein TiO_2 is contained in an amount of from 15 to 25%.
3. A flux-cored wire according to Claim 1, wherein Na_2O is contained in an amount of from 0.2 to 0.4%.
4. A flux-cored wire according to Claim 1, wherein the ratio of TiO_2 and Na_2O is in the range of from 40 to 80:1.
5. A flux-cored wire according to Claim 1, wherein said metal fluoride is a member selected from the group consisting of CaF_2 , NaF , AlF_3 , BaF_2 , Na_3AlF_6 , Na_2SiF_6 , K_2SiF_6 , K_2ZrF_6 , LiF_2 , MgF_2 , SrF_2 and mixtures thereof.
6. A flux-cored wire according to Claim 1, wherein the metal fluoride is contained in the range of from 0.1 to 1.0%.
7. A flux-cored wire according to Claim 1, wherein the moisture is contained in an amount of from 0.005 to 0.1%.
8. A flux-cored wire according to Claim 1, further comprising Bi_2O_3 in such a way that the ratio of Na_2O and Bi_2O_3 is in the range of 1 to 10:1.
9. A flux-cored wire according to Claim 8, wherein Bi_2O_3 is contained in an amount of from 0.01 to 0.6%.
10. A flux-cored wire according to Claim 1, further comprising at least one member selected from the group consisting of K_2O , SiO_2 , ZrO_2 , MgO , Al_2O_3 , MnO_2 , MnO , FeO , Fe_2O_3 , Fe_3O_4 , LiFeO_2 , Li_2SiO_3 , Li_2MnO_3 , B_2O_3 , Mn, Si, Al, Ni, Cr, Mo, Cu, B, Li, Fe and mixtures thereof.

Patentansprüche

1. Ein Flußmittelkerndraht zum Lichtbogenschweißen in Schutzgas, umfassend einen Stahlblechmantel und eine in den Stahlblechmantel eingefüllte Flußmittelmasse, wobei der Anteil des Flußmittels 8 bis 25 Gew.-% beträgt, und zwar umfaßt die Flußmittelmasse im Verhältnis zu dem Gewicht des gesamten Flußmittels 10 bis 30% TiO_2 , 0,1 bis 0,6% Na_2O , vorausgesetzt daß ein Verhältnis von TiO_2 zu Na_2O zwischen 20 und 100:1 beträgt, 0,01 bis 2,0% eines als F berechneten Metallfluorids und 0,005 bis 0,4% Feuchtigkeit.
2. Ein Flußmittelkerndraht nach Anspruch 1, in dem TiO_2 in einer Menge von 15 bis 25% enthalten ist.
3. Ein Flußmittelkerndraht nach Anspruch 1, in dem Na_2O in einer Menge von 0,2 bis 0,4% enthalten ist.
4. Ein Flußmittelkerndraht nach Anspruch 1, bei dem das Verhältnis von TiO_2 zu Na_2O zwischen 40 und 80:1 beträgt.
5. Ein Flußmittelkerndraht nach Anspruch 1, bei dem das besagte Metallfluorid ein aus der CaF_2 , NaF , AlF_3 , BaF_2 , Na_3AlF_6 , Na_2SiF_6 , K_2SiF_6 , K_2ZrF_6 , LiF_2 , MgF_2 , SrF_2 und Gemische davon umfassenden Gruppe ausgewählter Bestandteil ist.
6. Ein Flußmittelkerndraht nach Anspruch 1, in dem das Metallfluorid in einer Menge von 0,1 bis 1,0% enthalten ist.



7. Ein Flußmittelkerndraht nach Anspruch 1, in dem die Feuchtigkeit in einer Menge von 0,005 bis 0,1% enthalten ist.
8. Ein Flußmittelkerndraht nach Anspruch 1, des weiteren umfassend Bi_2O_3 so daß das Verhältnis von Na_2O zu Bi_2O_3 zwischen 1 bis 10:1 beträgt.
9. Ein Flußmittelkerndraht nach Anspruch 8, in dem Bi_2O_3 in einer Menge von 0,01 bis 0,6% enthalten ist.
10. Ein Flußmittelkerndraht nach Anspruch 1, des weiteren mit mindestens einem aus der K_2O , SiO_2 , ZrO_2 , MgO , Al_2O_3 , MnO_2 , MnO , FeO , Fe_2O_3 , Fe_3O_4 , LiFeO_2 , Li_2SiO_3 , Li_2MnO_3 , B_2O_3 , Mn , Si , Al , Ni , Cr , Mo , Cu , B , Li , Fe und Gemische davon umfassenden Gruppe ausgewählten Bestandteil.

Revendications

1. Fil à âme de flux pour le soudage à l'arc sous gaz protecteur, comprenant une gaine d'acier et une composition de flux remplissant l'âme d'acier à raison de 8 à 25% par poids, la composition de flux comprenant, sur la base du poids du flux total, 10 à 30% de TiO_2 , 0,1 à 0,6% de Na_2O , le rapport du TiO_2 au Na_2O étant dans la gamme de 20 à 100:1, 0,01 à 2,0% de fluorure de métal calculé en tant que F, et 0,005 à 0,4% d'humidité.
2. Fil à âme de flux selon Revendication 1, dans lequel la proportion de TiO_2 est de 15 à 25%.
3. Fil à âme de flux selon Revendication 1, dans lequel la proportion de Na_2O est de 0,2 à 0,4%.
4. Fil à âme de flux selon Revendication 1, dans lequel le rapport du TiO_2 au Na_2O est dans la gamme de 40 à 80:1.
5. Fil à âme de flux selon Revendication 1, dans lequel ledit fluorure de métal est un élément sélectionné dans le groupe constitué de CaF_2 , NaF , AlF_3 , BaF_2 , Na_3AlF_6 , Na_2SiF_6 , K_2SiF_6 , K_2ZrF_6 , LiF_2 , MgF_2 , SrF_2 et de mélanges de ceux-ci.
6. Fil à âme de flux selon Revendication 1, dans lequel la teneur en fluorure de métal est dans la gamme de 0,1 à 1,0%.
7. Fil à âme de flux selon Revendication 1, dans lequel la teneur en fluorure de métal est de 0,005 à 0,1%.
8. Fil à âme de flux selon Revendication 1, comprenant en outre du Bi_2O_3 de telle sorte que le rapport du Na_2O au Bi_2O_3 est dans la gamme de 1 à 10:1.
9. Fil à âme de flux selon Revendication 8, dans lequel la teneur en Bi_2O_3 est de 0,01 à 0,6%.
10. Fil à âme de flux selon Revendication 1, comprenant en outre un élément sélectionné dans le groupe constitué de K_2O , SiO_2 , ZrO_2 , MgO , Al_2O_3 , MnO_2 , MnO , FeO , Fe_2O_3 , Fe_3O_4 , LiFeO_2 , Li_2SiO_3 , Li_2MnO_3 , B_2O_3 , Mn , Si , Al , Ni , Cr , Mo , Cu , B , Li , Fe et des mélanges de ceux-ci.