







13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

Carcinogenesis

Carcinogenicity studies of dimethyl fumarate (DMF) were conducted in mice and rats. In mice, oral administration of DMF (25, 75, 200, and 400 mg/kg/day) for up to two years resulted in an increase in nonglandular stomach (forestomach) and kidney tumors: squamous cell carcinomas and papillomas of the forestomach in males and females at 200 and 400 mg/kg/day; leiomyosarcomas of the forestomach at 400 mg/kg/day in males and females; renal tubular adenomas and carcinomas at 200 and 400 mg/kg/day in males; and renal tubule adenomas at 400 mg/kg/day in females. Plasma MMF exposure (AUC) at the highest dose not associated with tumors in mice (75 mg/kg/day) was similar to that in humans at the recommended human dose (RHD) of 480 mg/day.

In rats, oral administration of DMF (25, 50, 100, and 150 mg/kg/day) for up to two years resulted in increases in squamous cell carcinomas and papillomas of the forestomach at all doses tested in males and females, and in testicular interstitial (Leydig) cell adenomas at 100 and 150 mg/kg/day. Plasma MMF AUC at the lowest dose tested was lower than that in humans at the RHD.

Mutagenesis

Dimethyl fumarate (DMF) and monomethyl fumarate (MMF) were not mutagenic in the *in vitro* bacterial reverse mutation (Ames) assay. DMF and MMF were clastogenic in the *in vitro* chromosomal aberration assay in human peripheral blood lymphocytes in the absence of metabolic activation. DMF was not clastogenic in the *in vivo* micronucleus assay in the rat.

Impairment of Fertility

In male rats, oral administration of DMF (75, 250, and 375 mg/kg/day) prior to and throughout the mating period had no effect on fertility; however, increases in non-motile sperm were observed at the mid and high doses. The no-effect dose for adverse effects on sperm is similar to the recommended human dose (RHD) of 480 mg/day on a body surface area (mg/m<sup>2</sup>) basis.

In female rats, oral administration of DMF (20, 100, and 250 mg/kg/day) prior to and during mating and continuing to gestation day 7 caused disruption of the estrous cycle and increases in embryolethality at the highest dose tested. The highest dose not associated with adverse effects (100 mg/kg/day) is twice the RHD on a mg/m<sup>2</sup> basis.

Testicular toxicity (germinal epithelial degeneration, atrophy, hypospermia, and/or hyperplasia) was observed at clinically relevant doses in mice, rats, and dogs in subchronic and chronic oral toxicity studies of DMF, and in a chronic oral toxicity study evaluating a combination of four fumaric acid esters (including DMF) in rats.

13.2 Animal Toxicology and/or Pharmacology

Kidney toxicity was observed after repeated oral administration of dimethyl fumarate (DMF) in mice, rats, dogs, and monkeys. Renal tubule epithelia regeneration, suggestive of tubule epithelial injury, was observed in all species. Renal tubular hyperplasia was observed in rats with dosing for up to two years. Cortical atrophy and interstitial fibrosis were observed in dogs and monkeys at doses above 5 mg/kg/day. In monkeys, the highest dose tested (75 mg/kg/day) was associated with single cell necrosis and multifocal and diffuse interstitial fibrosis, indicating irreversible loss of renal tissue and function. In dogs and monkeys, the 5 mg/kg/day dose was associated with plasma MMF exposures less than or similar to that in humans at the recommended human dose (RHD).

A dose-related increase in incidence and severity of retinal degeneration was observed in mice following oral administration of DMF for up to two years at doses above 75 mg/kg/day, a dose associated with plasma MMF exposure (AUC) similar to that in humans at the RHD.

14 CLINICAL STUDIES

The efficacy and safety of dimethyl fumarate delayed-release capsules were demonstrated in two studies (Studies 1 and 2) that evaluated dimethyl fumarate delayed-release capsules taken either twice or three times a day in patients with relapsing-remitting multiple sclerosis (RRMS). The starting dose for dimethyl fumarate delayed-release capsules was 120 mg twice or three times a day for the first 7 days, followed by an increase to 240 mg twice or three times a day. Both studies included patients who had experienced at least 1 relapse over the year preceding the trial or had a brain Magnetic Resonance Imaging (MRI) scan demonstrating at least one gadolinium-enhancing (Gd+) lesion within 6 weeks of randomization. The Expanded Disability Status Scale (EDSS) was also assessed and patients could have scores ranging from 0 to 5. Neurological evaluations were performed at baseline, every 3 months, and at the time of suspected relapse. MRI evaluations were performed at baseline, month 6, and year 1 and 2 in a subset of patients (44% in Study 1 and 48% in Study 2).

Study 1: Placebo-Controlled Trial in RRMS

Study 1 was a 2-year randomized, double-blind, placebo-controlled study in 1234 patients with RRMS. The primary endpoint was the proportion of patients relapsed at 2 years. Additional endpoints at 2 years included the number of new or newly enlarging T2 hyperintense lesions, number of new T1 hypointense lesions, number of Gd+ lesions, annualized relapse rate (ARR), and time to confirmed disability progression. Confirmed disability progression was defined as at least a 1 point increase from baseline EDSS (1.5 point increase for patients with baseline EDSS of 0) sustained for 12 weeks.

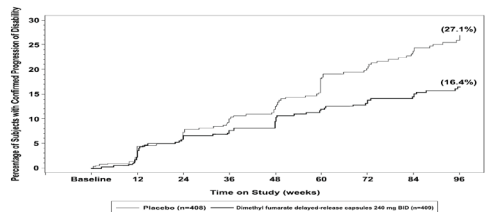
Patients were randomized to receive dimethyl fumarate delayed-release capsules 240 mg twice a day (n=416), dimethyl fumarate delayed-release capsules 240 mg three times a day (n=416), or placebo (n=408) for up to 2 years. The median age was 39 years, median time since diagnosis was 4 years, and median EDSS score at baseline was 2. The median time on study drug for all treatment arms was 96 weeks. The percentages of patients who completed 96 weeks on study drug per treatment group were 69% for patients assigned to dimethyl fumarate delayed-release capsules 240 mg twice a day, 69% for patients assigned to dimethyl fumarate delayed-release capsules 240 mg three times a day and 65% for patients assigned to placebo groups.

Dimethyl fumarate delayed-release capsules had a statistically significant effect on all of the endpoints described above and the 240 mg three times daily dose showed no additional benefit over the dimethyl fumarate delayed-release capsules 240 mg twice daily dose. The results for this study (240 mg twice a day vs. placebo) are shown in Table 2 and Figure 1.

Table 2: Clinical and MRI Results of Study 1

|                                                               | Dimethyl Fumarate Delayed-Release Capsules 240 mg BID | Placebo | P-value |
|---------------------------------------------------------------|-------------------------------------------------------|---------|---------|
| <b>Clinical Endpoints</b>                                     | N=410                                                 | N=408   |         |
| Proportion relapsing (primary endpoint)                       | 27%                                                   | 46%     | <0.0001 |
| Relative risk reduction                                       | 43%                                                   |         |         |
| Annualized relapse rate                                       | 0.172                                                 | 0.364   | <0.0001 |
| Relative reduction                                            | 53%                                                   |         |         |
| Proportion with disability progression                        | 16%                                                   | 27%     | 0.0050  |
| Relative risk reduction                                       | 38%                                                   |         |         |
| <b>MRI Endpoints</b>                                          | N=152                                                 | N=165   |         |
| Mean number of new or newly enlarging T2 lesions over 2 years | 2.6                                                   | 17      | <0.0001 |
| Percentage of subjects with no new or newly enlarging lesions | 45%                                                   | 27%     |         |
| Number of Gd+ lesions at 2 years                              | 0.1 (0)                                               | 1.8 (0) |         |
| Mean (median)                                                 |                                                       |         |         |
| Percentage of subjects with                                   |                                                       |         |         |
| 0 lesions                                                     | 93%                                                   | 62%     |         |
| 1 lesion                                                      | 5%                                                    | 10%     |         |
| 2 lesions                                                     | <1%                                                   | 8%      |         |
| 3 to 4 lesions                                                | 0                                                     | 9%      |         |
| 5 or more lesions                                             | <1%                                                   | 11%     |         |
| Relative odds reduction (percentage)                          | 90%                                                   |         | <0.0001 |
| Mean number of new T1 hypointense lesions over 2 years        | 1.5                                                   | 5.6     | <0.0001 |

Figure 1: Time to 12-Week Confirmed Progression of Disability (Study 1)



Study 2: Placebo-Controlled Trial in RRMS

Study 2 was a 2-year multicenter, randomized, double-blind, placebo-controlled study that also included an open-label comparator arm in patients with RRMS. The primary endpoint was the annualized relapse rate at 2 years. Additional endpoints at 2 years included the number of new or newly enlarging T2 hyperintense lesions, number of T1 hypointense lesions, number of Gd+ lesions, proportion of patients relapsed, and time to confirmed disability progression as defined in Study 1.

Patients were randomized to receive dimethyl fumarate delayed-release capsules 240 mg twice a day (n=359), dimethyl fumarate delayed-release capsules 240 mg three times a day (n=345), an open-label comparator (n=350), or placebo (n=363) for up to 2 years. The median age was 37 years, median time since diagnosis was 3 years, and median EDSS score at baseline was 2.5. The median time on study drug for all treatment arms was 96 weeks. The percentages of patients who completed 96 weeks on study drug per treatment group were 70% for patients assigned to dimethyl fumarate delayed-release capsules 240 mg twice a day, 72% for patients assigned to dimethyl fumarate delayed-release capsules 240 mg three times a day and 64% for patients assigned to placebo groups.

Dimethyl fumarate delayed-release capsules had a statistically significant effect on the relapse and MRI endpoints described above. There was no statistically significant effect on disability progression. The dimethyl fumarate delayed-release capsules 240 mg three times daily dose resulted in no additional benefit over the dimethyl fumarate delayed-release capsules 240 mg twice daily dose. The results for this study (240 mg twice a day vs. placebo) are shown in Table 3.

Table 3: Clinical and MRI Results of Study 2

|                                                               | Dimethyl Fumarate Delayed-Release Capsules 240 mg BID | Placebo | P-value |
|---------------------------------------------------------------|-------------------------------------------------------|---------|---------|
| <b>Clinical Endpoints</b>                                     | N=359                                                 | N=363   |         |
| Annualized relapse rate                                       | 0.224                                                 | 0.401   | <0.0001 |
| Relative reduction                                            | 44%                                                   |         |         |
| Proportion relapsing                                          | 29%                                                   | 41%     | 0.0020  |
| Relative risk reduction                                       | 34%                                                   |         |         |
| Proportion with disability progression                        | 13%                                                   | 17%     | 0.25    |
| Relative risk reduction                                       | 21%                                                   |         |         |
| <b>MRI Endpoints</b>                                          | N=147                                                 | N=144   |         |
| Mean number of new or newly enlarging T2 lesions over 2 years | 5.1                                                   | 17.4    | <0.0001 |
| Percentage of subjects with no new or newly enlarging lesions | 27%                                                   | 12%     |         |

|                                                        |           |           |         |
|--------------------------------------------------------|-----------|-----------|---------|
| Number of Gd+ lesions at 2 years                       |           |           |         |
| Mean (median)                                          | 0.5 (0.0) | 2.0 (0.0) |         |
| Percentage of subjects with                            |           |           |         |
| 0 lesions                                              | 80%       | 61%       |         |
| 1 lesion                                               | 11%       | 17%       |         |
| 2 lesions                                              | 3%        | 6%        |         |
| 3 to 4 lesions                                         | 3%        | 2%        |         |
| 5 or more lesions                                      | 3%        | 14%       |         |
| Relative odds reduction (percentage)                   | 74%       |           | <0.0001 |
| Mean number of new T1 hypointense lesions over 2 years | 3.0       | 7.0       | <0.0001 |

16 HOW SUPPLIED/STORAGE AND HANDLING

Dimethyl fumarate is available as hard gelatin delayed-release capsules in two strengths containing either 120 mg or 240 mg of dimethyl fumarate, USP. The 120 mg capsules are light blue opaque size '0' hard gelatin capsules imprinted with 'H' on cap and 'D12' on body filled with white to off white tablets. They are available as follows:

|                                                                                                                                                                                          |                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 30-day Starter Pack                                                                                                                                                                      | NDC 31722-680-60 |
| 7-day bottle 120 mg capsules, quantity 14                                                                                                                                                |                  |
| 23-day bottle 240 mg capsules, quantity 46                                                                                                                                               |                  |
| 120 mg capsules:                                                                                                                                                                         |                  |
| 7-day bottle of 14 capsules                                                                                                                                                              | NDC 31722-657-31 |
| Blister Pack of 100 (10x10) unit dose capsules                                                                                                                                           | NDC 31722-657-32 |
| The 240 mg capsules are white opaque size '0el' hard gelatin capsules imprinted with 'H' on cap and 'D15' on body filled with white to off white tablets. They are available as follows: |                  |
| 240 mg capsules:                                                                                                                                                                         |                  |
| 23-day bottle of 46 capsules                                                                                                                                                             | NDC 31722-658-31 |
| 30-day bottle of 60 capsules                                                                                                                                                             | NDC 31722-658-32 |
| Blister Pack of 100 (10x10) unit dose capsules                                                                                                                                           | NDC 31722-658-33 |
| Store at 20° to 25°C (68° to 77°F) [see USP Controlled Room Temperature]. Protect the capsules from light. Store in original container.                                                  |                  |

17 PATIENT COUNSELING INFORMATION

Advise the patient to read the FDA-approved patient labeling (Patient Information).

Dosage

Inform patients that they will be provided two strengths of dimethyl fumarate delayed-release capsules when starting treatment: 120 mg capsules for the 7-day starter dose and 240 mg capsules for the maintenance dose, both to be taken twice daily. Inform patients to swallow dimethyl fumarate delayed-release capsules whole and intact. Inform patients to not crush, chew, or sprinkle capsule contents on food. Inform patients that dimethyl fumarate delayed-release capsules can be taken with or without food [see Dosage and Administration (2.1)].

Anaphylaxis and Angioedema

Advise patients to discontinue dimethyl fumarate delayed-release capsules and seek medical care if they develop signs and symptoms of anaphylaxis or angioedema [see Warnings and Precautions (5.1)].

Progressive Multifocal Leukoencephalopathy

Inform patients that progressive multifocal leukoencephalopathy (PML) has occurred in patients who received dimethyl fumarate delayed-release capsules. Inform the patient that PML is characterized by a progression of deficits and usually leads to death or severe disability over weeks or months. Instruct the patient of the importance of contacting their doctor if they develop any symptoms suggestive of PML. Inform the patient that typical symptoms associated with PML are diverse, progress over days to weeks, and include progressive weakness on one side of the body or clumsiness of limbs, disturbance of vision, and changes in thinking, memory, and orientation leading to confusion and personality changes [see Warnings and Precautions (5.2)].

Herpes Zoster and Other Serious Opportunistic Infections

Inform patients that herpes zoster and other serious opportunistic infections have occurred in patients who received dimethyl fumarate delayed-release capsules. Inform the patient that PML is characterized by a progression of deficits and usually leads to death or severe disability over weeks or months. Instruct the patient of the importance of contacting their doctor if they develop any signs or symptoms associated with herpes zoster or other serious opportunistic infections [see Warnings and Precautions (5.3)].

Lymphocyte Counts

Inform patients that dimethyl fumarate delayed-release capsules may decrease lymphocyte counts. A blood test should be obtained before they start therapy. Blood tests are also recommended after 6 months of treatment, every 6 to 12 months thereafter, and as clinically indicated [see Warnings and Precautions (5.4), Adverse Reactions (6.1)].

Liver Injury

Inform patients that dimethyl fumarate delayed-release capsules may cause liver injury. Instruct patients treated with dimethyl fumarate delayed-release capsules to report promptly any symptoms that may indicate liver injury, including fatigue, anorexia, right upper abdominal discomfort, dark urine, or jaundice. A blood test should be obtained before patients start therapy and during treatment, as clinically indicated [see Warnings and Precautions (5.5)].

Flushing

Inform patients that flushing is one of the most common reactions, especially at the initiation of therapy, and may decrease over time. Advise patients to contact their healthcare provider if they experience persistent and/or severe flushing. Advise patients experiencing flushing that taking dimethyl fumarate delayed-release capsules with food or taking a non-enteric coated aspirin prior to taking dimethyl fumarate delayed-release capsules may help [see Adverse Reactions (6.1)].

Gastrointestinal (GI) Events

Inform patients that GI events (abdominal pain, diarrhea, and nausea) are some of the most common adverse reactions, especially at the initiation of therapy, and may decrease over time. Some patients may experience more severe GI events. Advise patients to immediately contact their healthcare provider and discontinue dimethyl fumarate delayed-release capsules if they experience gastrointestinal bleeding (e.g., rectal bleeding, bloody diarrhea, hematemesis) or other serious gastrointestinal adverse events (e.g., severe abdominal pain, severe vomiting and/or diarrhea) [see Warnings and Precautions (5.7)].



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Patient Information

Dimethyl Fumarate (dye meth il FYOO ma rate)  
Delayed-Release Capsules, USP

What are dimethyl fumarate delayed-release capsules?

- Dimethyl fumarate delayed-release capsules are a prescription medicine used to treat relapsing forms of multiple sclerosis (MS), to include clinically isolated syndrome, relapsing-remitting disease, and active secondary progressive disease, in adults.
- It is not known if dimethyl fumarate delayed-release capsules are safe and effective in children under 18 years of age

Who should not take dimethyl fumarate delayed-release capsules?

- Do not use dimethyl fumarate delayed-release capsules if you have had an allergic reaction (such as welts, hives, swelling of the face, lips, mouth or tongue, or difficulty breathing) to dimethyl fumarate delayed-release capsules or any of its ingredients. See below for a complete list of ingredients.

Before taking and while you take dimethyl fumarate delayed-release capsules, tell your doctor if you have or have had:

- low white blood cell counts or an infection
- any other medical conditions

Tell your doctor if you are:

- pregnant or plan to become pregnant. It is not known if dimethyl fumarate delayed-release capsules will harm your unborn baby. You and your doctor will have to decide if you should take dimethyl fumarate delayed-release capsules while you are pregnant or if you plan to become pregnant.
- breastfeeding or plan to breastfeed. It is not known if dimethyl fumarate passes into your breast milk. You and your doctor should decide if you will take dimethyl fumarate delayed-release capsules or breastfeed.
- taking prescription or over-the-counter medicines, vitamins, or herbal supplements

How should I take dimethyl fumarate delayed-release capsules?

- Take dimethyl fumarate delayed-release capsules exactly as your doctor tells you to take them
- The recommended starting dose is one 120 mg capsule taken by mouth 2 times a day for 7 days
- The recommended dose after 7 days is one 240 mg capsule taken by mouth 2 times a day

- Dimethyl fumarate delayed-release capsules can be taken with or without food
- Swallow dimethyl fumarate delayed-release capsules whole. Do not crush, chew, or sprinkle capsule contents on food.
- Protect dimethyl fumarate delayed-release capsules from light. You can do this by storing the capsules in their original container.
- If you take too much dimethyl fumarate, call your doctor or go to the nearest hospital emergency room right away.

What are the possible side effects of dimethyl fumarate delayed-release capsules?

Dimethyl fumarate delayed-release capsules may cause serious side effects including:

- **allergic reaction** (such as welts, hives, swelling of the face, lips, mouth or tongue, or difficulty breathing)
- **PML** a rare brain infection that usually leads to death or severe disability
- **decreases in your white blood cell count** Your doctor should do a blood test before you start treatment with dimethyl fumarate delayed-release capsules and while on therapy.
- **liver problems.** Your doctor should do blood tests to check your liver function before you start taking dimethyl fumarate delayed-release capsules and during treatment if needed. Tell your doctor right away if you get any of these symptoms of a liver problem during treatment.
  - severe tiredness
  - loss of appetite
  - pain on the right side of your stomach
  - have dark or brown (tea color) urine
  - yellowing of your skin or the white part of your eyes
- **herpes zoster infections (shingles)**, including central nervous system infections
- **other serious infections**
- **serious gastrointestinal problems**, including bleeding, ulcers, blockage, and tears (perforation) of the stomach or intestines. Tell your healthcare provider right away if you have any of these symptoms during treatment:
  - Stomach-area pain that does not go away
  - Bright red or black stools (that look like tar)
  - Severe vomiting
  - Severe diarrhea
  - Coughing up blood or blood clots
  - Vomiting blood or your vomit looks like “coffee grounds”

The most common side effects of dimethyl fumarate delayed-release capsules include:

- flushing, redness, itching, or rash
- nausea, vomiting, diarrhea, stomach pain, or indigestion. These events can be serious in some patients (see “dimethyl fumarate delayed-release capsules may cause serious side effects including,” above).
- Flushing and stomach problems are the most common reactions, especially at the start of therapy, and may decrease over time. Taking dimethyl fumarate delayed-release capsules with food may help reduce flushing. Call your doctor if you have any of these symptoms and they bother you or do not go away. Ask your doctor if taking aspirin before taking dimethyl fumarate delayed-release capsules may reduce flushing.

These are not all the possible side effects of dimethyl fumarate delayed-release capsules. Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088. For more information go to [dailymed.nlm.nih.gov](http://dailymed.nlm.nih.gov).

General Information about the safe and effective use of dimethyl fumarate delayed-release capsules

- Medicines are sometimes prescribed for purposes other than those listed in this Patient Information. Do not use dimethyl fumarate delayed-release capsules for a condition for which it was not prescribed. Do not give dimethyl fumarate delayed-release capsules to other people, even if they have the same symptoms that you have. They may harm them.
- If you would like more information, talk to your doctor or pharmacist. You can ask your doctor or pharmacist for information about dimethyl fumarate delayed-release capsules that is written for healthcare professionals.

What are the ingredients in dimethyl fumarate delayed-release capsules?

**Active ingredient:** dimethyl fumarate

**Inactive ingredients:** calcium silicate, colloidal silicon dioxide, croscarmellose sodium, gelatin, magnesium stearate, methacrylic acid and ethyl acrylate copolymer, methacrylic acid and methyl methacrylate copolymer, poloxamer, polysorbate 80, silicified microcrystalline cellulose, sodium bicarbonate, sodium lauryl sulfate, talc, titanium dioxide and triethyl citrate. In addition, the 120 mg capsules also contain FD&C Blue 1, iron oxide black and iron oxide yellow.

The imprinting ink contains the following inactive ingredients: black iron oxide, potassium hydroxide, propylene glycol, shellac and strong ammonia solution.



Manufactured for:  
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For more information, call Hetero Labs Limited at 1-866-495-1995.

This Patient Information has been approved by the U.S. Food and Drug Administration.

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